THE JOURNAL *of*
LOWER LIMB
MEDICINE

EXTREMITAS

VOL. 7 MAY 2020

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Journal of Lower Limb Medicine

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Dr. Jarrod Shapiro

This student-run journal would not be possible without your support and mentorship. Thank you for continuing to give the students this unique opportunity to work and learn together.

LETTER FROM THE EDITOR

Dear Readers,

This edition marks a trying time in all of our lives as the COVID-19 pandemic spread across the world earlier this year. Throughout campus, students and administration have had to leave our classrooms and offices and many irreplaceable events were cancelled. For some of our editors, this meant completing their second year from home and preparing for a board exam that might be postponed. For others, it meant not knowing when we would start our most exciting year as fourth-year externs. The sacrifices and changes in the last few months have left us wondering what the future will hold.

For the Extremitas team, our efforts were stalled but not stopped. We worked hard to bring you this latest edition of Extremitas. Each paper endured several rounds of rigorous editing by our entire team. The articles will take you through an array of topics ranging from injuries and surgical options in popular sports to uncommon infectious pathogens. I am so proud to present this tremendous collection of work.

We are thankful for our faculty and administration who continue to support the students throughout this pandemic. We are especially grateful for our Dean, Dr. Kathleen Satterfield, who has shared unwavering positivity and encouragement as we try to navigate an unclear future. I also want to thank the Extremitas team for their endurance and patience under these unique circumstances. Lastly, we are indebted to the frontline healthcare workers who are setting an example of courage and perseverance that we hope to emulate when we finally join the medical community.

Sincerely,

EDITOR IN CHIEF
Kira Cramer
DPM Candidate 2021

REFLECTIONS FROM THE TEAM

"With each edition, Extremitas continues to provide an outlet for WesternU students to share their passion for research and lower limb medicine. I hope that the hard work and dedication of our students in this seventh issue of Extremitas serves as a beacon of hope and inspiration during these unprecedented times." *Elnaz Hamedani, DPM Candidate 2021*

"Thank you to everyone who supported the 2020 edition of Extremitas! I'm proud of the WesternU family for coming together to complete and publish Extremitas this year despite new challenges and uncertainties on top of our rigorous coursework. Collectively, we have put together another wonderful and informative publication and we hope you enjoy the 7th edition of Extremitas: Journal of Lower Limb Medicine!" *Brittany Nguyen, DPM Candidate 2021*

"I truly enjoyed reading the impressive works created by our student body. The effort our contributors have taken is what makes our university and publication great."
Shiv Patel, DPM Candidate 2021

"The editing process for me has been a challenging and rewarding experience. As a writer and researcher, myself, seeing the other side of the process is illuminating to all the hard work that takes place in the creation of a journal. I would personally like to thank the entire editing team for making the process enjoyable. Remember, when in doubt, cite your source. "
Garrett Wireman, DPM Candidate 2021

"It has been an honor to work with Dr. Shapiro and the Extremitas team the last two years. Thank you to all our sponsors and authors that contributed to Extremitas this year."
Tien Nguyen, DPM Candidate 2021

"Thank you to our amazing faculty, contributors, sponsors, and editors for supporting our publication. This edition of Extremitas represents a unique time in our lives and we are grateful to play a role in the making of it. We hope you enjoy the 7th edition of Extremitas: Journal of Lower Limb Medicine." *Alexis Conley, DPM Candidate 2021*

"Having had the privilege of serving as assistant editor was a great honor. The experience was highly valuable, both because it taught me more about podiatric medicine and because of how it shaped my approach on how to critically read and analyze articles." *Dy Chin, DPM Candidate 2022*

"Becoming an assistant editor of Extremitas pushed me to develop new skills, but I was lucky to work alongside an awesome team. I am excited to be a part of this WesternU experience and encourage everyone to join the team next year." *Anthony Wright, DPM Candidate 2022*

"Being a part of the team this year has been a wonderful opportunity and I'm grateful for what I've learned in my role. I'd like to thank the editorial team and those who made submissions for their hard work which has brought together this year's amazing edition!" *Faiza Zahid, DPM Candidate 2022*

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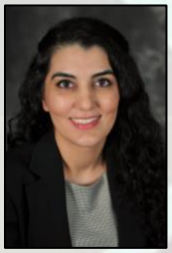

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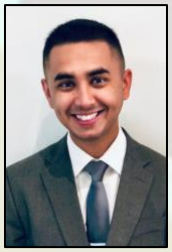

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The Modified Krackow Technique: A Case Presentation

Elnaz Hamedani[+], B.A., B.S., Daliya Heng[+], B.A., and Vivek Kommineni[+], B.A.

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objective: Achilles tendon ruptures are one of the most common lower extremity injuries. There are various suture techniques that are classically used for the surgical repair of the Achilles tendon. The purpose of this case presentation is to show the efficacy and strength of a modified Krackow suture, commonly referred to as the gift box technique, for repairing an Achilles tendon rupture.

Case report: In this case presentation, the gift box technique was used to repair an Achilles tendon rupture at Olive View UCLA Medical Center. Intraoperatively, a V-Y advancement of the gastro-soleus fascia was utilized for a turn-down flap to accommodate the large deficit in the Achilles tendon. Post-operatively, the patient was non-weightbearing for six weeks while gradually transitioning to weightbearing with physical therapy. There were no adverse complications or re-rupture of the Achilles tendon reported.

Discussion: Few in vivo studies have been conducted on the gift box technique, however, in cadaveric studies, the gift box technique has been shown to be stronger than the original Krackow suture. Additionally, in retrospective studies in which patients were treated with the gift box method, patients reported satisfaction with the treatment and denied any adverse events or re-rupture of the Achilles tendon.

Conclusion: The gift box technique provides twice the suture strength as the traditional Krackow suture. The successful repair of the Achilles tendon in this case presentation, in addition to the results of recent literature that show the effectiveness of the gift box technique in vitro, suggests that it is a promising alternative suture technique for Achilles repairs.

Introduction

The Achilles tendon is the thickest tendon in the human body, spanning from the gastrocnemius and soleus muscles to the calcaneal tuberosity.[1] Despite its thickness and size, Achilles ruptures are one of the most common athletic injuries.[1] Ruptures of the Achilles tendon often present with a snapping sensation felt in the posterior ankle. Patients tend to experience difficulty with weightbearing and climbing stairs with the affected extremity.[2] On clinical examination a visible dell is seen on the affected posterior ankle and a gap is palpable between the ruptured tendon ends.[2] The most common site of injury for an Achilles rupture is 2 to 6 cm proximal to the posterior calcaneus.[2] This area has increased susceptibility to tendon rupture because it is hypovascular and has been termed the "watershed area" by Lagergren and Lindholm.[2]

Two different theories have been proposed for the mechanism of Achilles tendon injuries. The Mechanical Stress Theory by Inglis and Sculco proposes that there is a malfunction in muscle mechanisms that prevent excessive tension and muscle overload causes rupture.[2] The Degenerative Theory proposes that repetitive trauma at the hypovascular regions of the Achilles tendon causes degenerative changes increasing the likelihood of tendon rupture.[2]

Regardless of the mechanism of injury, the loss of structural integrity and strength causes the rupture. Hence, it can be inferred that any surgical correction will require a suture technique with sufficient strength to allow for early range of motion and return of function.

There are various suture techniques that can be used for Achilles repairs. The most commonly utilized sutures are the Kessler, the Bunnell, and the Krackow.[3] Although these suture types have been proven to be successful in Achilles repair, a recent suture technique has emerged, which is a modification of the Krackow and is commonly referred to as the gift box technique.

In this case report, we present a patient who underwent Achilles tendon rupture repair using the gift box technique and discuss the efficacy and strength of this modified Krackow suture. Our case report of the gift box suture shows that this technique is a promising alternative suture technique for Achilles rupture repairs.

Patient Case

History and Presentation

A 2019 surgical case at Olive View UCLA Medical Center examined the use of the gift box technique on a patient with an Achilles rupture. The patient was a 45-year-old man who presented to the clinic because he had continued difficulty with walking and climbing stairs. The patient had sustained the Achilles injury one year prior to his clinic visit, while playing basketball. He stated that he initially experienced severe pain in his right calf and fell to the ground. However, as hours passed the

pain diminished. The patient had no pertinent past medical, surgical, or social history to report and the physical exam findings were unremarkable except for the musculoskeletal exam. A visible dell was present on the right posterior ankle, in addition to a positive resting flexion exam and a positive O'Brien's needle exam on the right calf. The patient also had an abducted and antalgic gait. The diagnosis of right Achilles rupture was further confirmed with radiographic and MRI imaging.

Surgical Technique

Prior to the procedure, the patient was placed under general anesthesia and administered a prophylactic dose of 2g cefazolin. He was positioned prone on the operating table, a tourniquet was placed on the right thigh, and the right leg was prepped appropriately following sterile guidelines. Incision approach was taken posteromedial to avoid the sural nerve. Meticulous dissection was performed on the right lower extremity. The right Achilles tendon deficit was visualized intraoperatively as seen in Figure 1.

Figure 1: *Intraoperative dissection of the right posterior calf indicating an Achilles tendon deficit.*

Figure 2: *Intraoperative measurements of the right Achilles tendon deficit after surgical debridement and irrigation*

After surgical debridement and irrigation of non-viable tissue, a larger and more pronounced deficit was appreciated as indicated in Figure 2. Due to the substantial gapping between the two tendon ends, a V-Y advancement of gastro-soleus fascia was utilized for a turn-down flap to resolve the deficit as shown in Figure 3. Figure 4 reveals the length of the turn down flap and preparation for the gift box technique repair. The two ends of the ruptured Achilles tendon were sutured together using the modified Krackow gift box technique. The final Achilles repair with the gift box technique is shown in Figure 5. Upon completion of surgery, the patient was placed in a posterior splint with the foot slightly plantarflexed.

Figure 3: *V-Y advancement flap used due to large deficit*

Figure 4: *Preparation of Flap down advancement for Achilles tendon repair with gift box technique*

Figure 5: *Final appearance of Achilles tendon repair with gift box technique*

Post-Operative Follow-Up

Postoperatively, the patient was instructed to remain non-weight bearing for at least six weeks and was prescribed hydrocodone for pain management as needed. The patient was seen one week post-operatively to assess healing. He presented to the clinic ambulating with a knee scooter for the right leg. The posterior splint was removed in clinic to evaluate the progression of the surgical site. The patient was tender to palpation, with sutures intact, and no dehiscence or signs of infection. He reported no adverse fever, nausea, or vomiting post operatively and was taking the prescribed pain medications. The patient was placed back in a posterior splint with the foot slightly plantarflexed and was instructed to return the following week for potential suture removal.

The patient continued to be followed postoperatively in clinic. During the second week postoperative visit, the patient presented with sutures and posterior splint intact and did not have any signs of infection. At this time, sutures and posterior splint were removed and the patient was placed in a CAM boot and instructed to continue non-weightbearing until his appointment with physical therapy.

Since the surgery, the patient has been progressing well and has not had any signs of infection or re-rupture of the Achilles tendon. He has been continuing his physical therapy and gradually transitioned to weight bearing after 6 weeks post-operatively. At this time, the patient states that he is satisfied with the overall outcome of the surgery.

Discussion

In the traditional Krackow method, two sutures are utilized with one suture for the proximal stump and another for the distal stump. The sutures are placed with two or more locking loops on each side of the tendon with the free ends of the sutures emerging at the site of the defect.[4] At this point, the defect is reduced and the sutures are tied to each other. With the gift box technique, the sutures are not tied at the level of the defect, rather Keith needles are used to pass the pair of free end suture through the opposing tendon one limb superficially and one deep to the opposite transverse limb. The defect is reduced and the sutures are then tied proximal to locking sutures in the proximal stump and distal to the sutures in the distal stump. While sutures are tied to one another at the ruptured ends in the traditional method, the gift box technique ties the suture ends of the same suture to themselves away from the rupture site.[4]

The modified Krackow technique was studied for strength by the Department of Orthopedic Surgery at Emory University.[4] Using 13 pairs of Achilles tendons, the gift box technique was compared with the existing Krackow technique. From each pair of Achilles tendons, one tendon was utilized to test the traditional Krackow technique while the other tendon was utilized to test the modified technique. This was done to ensure comparable tendons were tested in each technique. The main difference between the two techniques is the placement of suture knots, with the Krackow technique having the knots placed at the level of the Achilles tendon defect, whereas the gift box technique places the knots proximal and distal to the defect.[4]

After repair, the strength of the sutures was tested with a loading frame device. The proximal end of the tendon was fixed with a “C” clamp and the calcaneal end was fixed with bone pins and a clamp.[4] This modification resulted in a greater force required for failure. The traditional method mean force required for failure was 81 N, whereas the mean force required for failure of the repair of the gift box technique was more than double at 168 N.[4]

There are a few limitations with this study. Being a level five cadaveric study, the study design did not include living participants. Hence, the overall effectiveness and long-term viability of this suture technique cannot be assessed by this study alone. Another limitation of this study is the mean age of

the harvested cadaveric Achilles tendons. The average age of the harvested tendons was 88 years old, whereas the Achilles tendon ruptures occur mainly between the third and fifth decades of life.[4] Although care was taken to create an Achilles tendon defect in the watershed zone, the defect was created with a single transverse cut. However, in vivo tendon ruptures have a significant amount of tendon and muscle fiber fraying which needs to be addressed.[4]

The gift box technique has also been studied in a 2016 study by Labib et al., which retrospectively reviewed the clinical results for patients who underwent this treatment for acute Achilles tendon ruptures.[3] In this study, 44 patients underwent treatment with the gift box suturing technique from March 2002 to April 2007. The primary inclusion criteria for this study was Achilles tendon ruptures less than 30 days old. All patients who had Achilles injuries greater than 30 days old, a prior history of Achilles injury, current corticosteroid use, immunosuppression, or prior Achilles surgical history were excluded from the study.[3]

Following surgical repair of the Achilles tendon with the gift box technique, patients were advised to complete a survey about their experience. Of the 44 patients who underwent Achilles tendon repair with the gift box technique, 35 patients completed the survey and only 20 returned to clinic for follow-up and examinations.[3] Additionally, six patients did not wish to participate in the study after receiving treatment, however, they stated that they did not experience re-rupture of the treated Achilles tendon.[3] Patients completed the Foot Function Index (FFI) and the American Orthopaedic Foot and Ankle Society Ankle Hindfoot Scale (AOFAS).[3]

For the 35 patients who completed the surveys, the FFI score had a range of 0 to 53.9, with an average score of 7.0 ± 10.5.[3] When interpreting FFI scores, smaller numerical values represent normal foot function. The AOFAS score had a range from 75 to 100, and an average score of 93.2 ± 6.8. An AOFAS score of 100 is the maximum score possible and indicates a healthy foot and ankle without pain or decreased function.[3]

Clinically, the site of the Achilles tendon rupture was measured from medial to lateral postoperatively as well as the calf circumference of both the affected and unaffected side. The calf circumference was measured 10 cm distal to the tibial tuberosity.[3] For the limb that underwent Achilles tendon repair, the mean calf girth was 39.09 ± 13.57 cm and the Achilles tendon had a width of 27.83 ± 7.84 mm. Whereas, the mean calf girth for the control limb was 41.87 ± 12.15 cm and the Achilles tendon width was 22.03 ± 9.25 mm.[3] A paired t-test was used to compare the measurements of the affected and unaffected limb and the resultant p-value for calf girth was 0.04 and 0.001 for the Achilles tendon width.[3] Lastly, none of the 44 patients reported post-operative complications such as infections, nerve damage, or re-rupture of the Achilles tendon.[3]

In this 2016 study, Labib et al. depicted that the gift box technique can be used to successfully repair Achilles tendon ruptures. All patients in this study reported satisfaction with their surgical treatment and there were no complications post-operatively in the patient population. However, a primary limitation of this study is the relatively small sample size with only 44 participants. For future studies, it would be ideal to have a larger sample size and to compare the gift box technique with other commonly used suture types, since this study did not provide any comparison between various techniques.

Although the gift box technique is a stronger alternative to the traditional suture, there continues to be modification of suture techniques for Achilles repair. A 2019 study by Tian et al. compareed the gift box technique with the locking block modified Krackow suture (LBMK) to determine if one technique is significantly stronger than the other.[5] In this level five cadaveric study, Tian et al. used dynamic tensile testing to apply loading forces to each suture type. A total of 20 bovine cadaveric tendons were used, 10 of which were subjected to the gift box technique and 10 to LBMK. The tendons underwent a loading force using a dynamic loading force device.[5]

The loading protocol was designed to mimic the amount of force that would be placed on the tendons during a physical rehabilitation program. In the first cycle of force loading, 20N of force was initially applied for five minutes, followed by 500 cycles of cyclical loading that ranged from 20-100N.[5] After the first cycle was completed, a second cycle of force loading applied 20-190N at 1 Hz for 500 cycles.[5] In order to better relate these cycles with the natural forces that are applied to the Achilles tendon, the authors mention that passive ankle flexion subjects the Achilles tendon to 20-100N of force, while the act of walking with a one-inch heel lift applies approximately 190N of force to the Achilles tendon.[5] After each loading cycle, the tendons were examined for ruptures and gapping between the sutures.

Both the LBMK and the gift box suture technique did not have any tendon ruptures or loading failures during the first 500 cycles.[5] After the first 500 cycles of loading, when the tendons were subjected to 20-100N of force, the LBMK had 0.76 ± 0.44 mm gapping while the gift box suture had 0.86 ± 0.47 mm gapping.[5] After an additional 500 cycles of 20-190N loading forces, the LBMK had gapping

of 3.68 ± 1.08 mm, whereas the gift box technique had 4.07 ± 1.28 mm gapping.[5] Additionally, during the second cycle of loading forces, the LBMK had two tendon failures while the gift box technique had three tendon failures.[5]

Although the LBMK technique had less gapping on average compared to the gift box technique, the differences between the two techniques are not statistically significant as the measured p-value was 0.466.[5] One advantage of the LBMK to the gift box technique is that the LBMK is less invasive which might promote better healing in patients. The locking block modified Krackow technique may be a viable alternative to the gift box technique, however, this cadaveric study does have certain limitations that prevent it from being an accurate representation of in vivo Achilles function and rehabilitation. To date, there are no in vivo studies that measure the efficacy of the LBMK technique, however, there have been studies of the gift box technique in patient care.[5] Additional in vivo studies, preferably prospective clinical trials, are necessary to determine if there is a significant difference between the gift box and the locking block modified Krackow suture.

Conclusion

As one of the most common athletic injuries, Achilles tendon treatment is an important aspect of foot and ankle patient care. Due to the loss of structural integrity at the level of the Achilles tendon rupture, a strong suture technique is necessary for early range of motion and return of function. Compared to the traditional Krackow suture, the gift box technique has been proven to be twice as strong. The successful repair of the Achilles tendon in this case presentation, in addition to the results of various studies, suggests that the gift box technique can be a promising alternative for Achilles repair. Future research should focus on in vivo retrospective studies with a larger sample size to provide a more detailed understanding of how the gift box compares to traditional techniques.

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The Effectiveness of Prophylactic Ankle Bracing for Basketball Players and its Impact on Performance

Martin Jameson Willems+, B.A.

+Western University of Health Sciences, College of Osteopathic Medicine of the Pacific-Northwest

ABSTRACT

Objective: To summarize the current literature on the effectiveness of prophylactic ankle bracing in preventing ankle injuries and its effect on performance in basketball players

Methods: A PubMed search was conducted on research related to prophylactic ankle bracing in basketball players across all levels of play.

Results: Preventative ankle bracing is correlated to a 70% decrease in occurrence of acute ankle injuries for athletes with and without a history of ankle injury. Current research suggests ankle bracing relates to an overall impairment of performance, but this can be weighed against the fact that dynamic postural control, attitude towards bracing, and single leg functional test performance will improve with prolonged use over the course of a season.

Conclusion: Prophylactic ankle bracing is effective in reducing the incidence of injury, regardless of injury history, but at some cost to performance. Psychological perspective surrounding the brace, dynamic postural control, and single leg functional performance does improve over the course of a season. The benefits of prophylactic ankle bracing should be weighed against the negative impact on performance. A lace up brace can be recommended for athletes who are interested in the least impairment of overall performance and a stirrup type brace could be recommended for those who primarily value vertical leaping ability.

Introduction

Ankle bracing or taping is commonly used prophylactically against acute ankle injuries as well as to prevent the recurrence of ankle injuries. Ankle sprain injuries are common injuries in basketball, even at the highest levels of play. From the 2013-14 season to the 2016-2017 season, approximately 26% of NBA players were affected by ankle injuries. [1] A study by Mcguine et al. evaluated the effect of ankle brace use on ankle injury rates in football players and concluded that players who used ankle braces had a lower incidence of acute ankle injuries. [2] Frey et al. studied prophylactic ankle brace use in high school volleyball players and found that using an ankle brace did not significantly alter the incidence of ankle sprains.[3] Gross et al. evaluated the overall role of ankle bracing in preventing ankle sprain injuries, using existing literature from a clinical perspective. [4]

The athlete's perception around the comfort of the brace and its impact on performance could impact compliance. The goal of this study is to summarize the relationships between ankle bracing and performance in basketball players exclusively, across all levels of play.

No studies were found to summarize the relationship between prophylactic ankle bracing in prevention and the impact it has on performance. When athletes make the decision to use ankle bracing as a preventative measure, it is pertinent to know what impact this will have on their performance. The purpose of this paper is to discuss the effectiveness of prophylactic ankle bracing for basketball players and how it impacts their performance.

Methods

A PubMed search was conducted with the keywords "Preventative Ankle Bracing Basketball" and "Ankle Brace Performance Basketball." The literature was searched for studies emphasizing injury and performance outcomes among basketball players across all levels of play. Publication language was limited to English. There were no restrictions on publication date. Articles that did not answer how effective ankle braces are in preventing injury and how ankle braces affect performance were excluded.

Results

Preventing Injury

Sitler et al. studied the efficacy of ankle bracing in reducing ankle sprain injury by conducting a randomized clinical study involving 1,601 United States Military Academy Cadets participating in intramural basketball. [5] Shoe type, athletic surface, and prior ankle injury were either statistically or experimentally controlled. and injury diagnosis was performed by orthopedic surgeons. All participants were placed in a standardized stirrup brace, which consists of a medial and lateral upright support connected by Velcro. The study reported 46 ankle injuries, 11 occurred in the braced group and 35 in the control group, which was a statistically significant difference. The ankle injury rate was 1.6 per 1,000 athlete exposures in the braced group and 5.2 in the control group. Knee injuries were also

observed in the study, eight were in the control group and nine were in the braced group. When evaluating the mode of each injury, it was determined that 87% occurred as a result of inversion with no significant difference between the two groups. Contact injuries were significantly less common in the braced group. This study included the psychological perspective on ankle bracing and found that initially 52% of the braced athletes had a favorable attitude towards the brace and by the end of the season, 70% had a positive attitude towards it.

In additional research, McGuine et al. conducted a study assessing the effect of ankle bracing in preventing injury in high school basketball players. [6] Participants were 1,460 male and female athletes from 46 high schools in Wisconsin. Shoe type was not controlled and was only classified as low-top or mid-top. Ankle taping was allowed, but the effects were negligible as it was used by less than 0.05% of the participants. Also, only one participant in each the braced group and control group sustained an ankle injury while using tape. Ankle injuries were evaluated by athletic trainers at the respective schools. The ankle brace chosen for the study was a lace up style ankle brace. The study found that prophylactic use of lace-up ankle braces reduced the frequency of ankle injuries in both male and female high school basketball athletes both with and without a history of ankle injury. Participants with a prior ankle injury suffered acute ankle injuries 60% less often when braced and participants without a prior ankle injury suffered acute ankle injuries 70% less often when braced. Injury severity was rated by number of days lost. The median number of days lost in the control group was six days, compared with five days in the braced group. This difference was not statistically significant.

Effect on Performance

Crocket and Sandry evaluated the long-term effects on dynamic postural control and single leg functional tests when using an ankle brace over the course of a basketball season. [7] The study involved 21 healthy male and female high school basketball players. Postural control was measured using the Star Excursion Balance Test and functional tests including the single leg crossover hop, single leg vertical jump, and single leg six-meter hop for time. Participants wore a lace up ankle brace. At the end of the 16-week season, with prophylactic ankle brace use, the performance in the Star Excursion Balance Test increased from pretest to posttest in all directions. The average distance increased for the single-leg triple crossover, and single leg vertical jump, while time decreased for the single-leg six-meter hop for time.

Mackean et al. evaluated the effect of different forms of ankle stabilization on basketball related performance tests. [8] The functions evaluated were vertical jump, jump shot, sprinting, and submaximal treadmill run. The participants were all females between the ages of seventeen and twenty-five. The different types of ankle support evaluated were tape, no support, a lace up brace and two different stirrup braces. The study found that the success on the metabolic and performance tests was significantly impaired by all types of ankle support. The highest average rank was seen when no support was used. The support type with the least impairment on performance was a stirrup brace and the support type with the most impairment on performance was the lace up brace. Vertical jump with no support was 252 cm, with stirrup braces was 250 and 251, and with the lace up brace was 249. Made baskets out of 10 attempted jump shots with no support was 6.6, with the stirrup braces was 6.6 and 6.8, and with the lace up brace was 5.5. Sprint time with no support was 27.9 sec, with the stirrup braces was 28.5 sec and 28.8 sec, and with the lace up brace was 28.5 sec. In the submaximal treadmill run, ankle support did significantly impact energy expenditure with the Stirrup brace requiring the highest energy cost and the taped ankle having the lowest energy cost.

Discussion

The results of Sitler et al. and McGuine et al. concluded that prophylactic ankle bracing is effective in preventing incidence of ankle injury, but not in changing the severity of the injury. [5,6] This study also found that ankle bracing would reduce the risk of injury in athletes both with and without a history of prior ankle injury. This finding contradicts the study by Yang et al., which found that incidence of ankle injury, while braced, was higher in athletes with no history of ankle injury. [9] However, this study by Yang et al. involved athletes from numerous sports and used a self-report, as opposed to evaluation by athletic trainers and orthopedic surgeons. [9] Sitler et al. studied the psychological component of prophylactic ankle bracing that Mcguine et al. did not. [5,6] The finding that a positive outlook on ankle bracing occurs with increased use can be taken into account when athletes are initially deciding to use prophylactic ankle braces.

When deciding to wear ankle braces as a preventative measure, impact on performance is an important consideration for athletes. The findings of the Crockett and Sandry study suggest that wearing a lace up ankle brace over the course of the season is related to an increase in performance in dynamic postural control and single leg functional tests. [7] Limitations of this study include the lack of control

and small sample size. With no control group for comparison, it is possible that the improvement came as a result of the training that occurred during workouts, practices, and games over the course of the season. At the very least, improvement in performance was not impeded by bracing. The results of this study by Crockett and Sandry found improvement in performance over time, while Mackean et al. concluded that ankle braces contribute to a significant impairment of performance. [7,8] The focus of this paper has been on ankle braces instead of taping as it has been found that after ten minutes of use, taping loses up to 50% of its initial restriction.[10]

Current research demonstrates that prophylactic ankle bracing is effective in reducing injuries, but the results of the Mackean et al. study suggest that ankle bracing does come at some cost to performance. [8] The findings of this study are useful to athletes when comparing what types of ankle stabilization to use. Vertical jump was significantly impaired when ankles were taped as opposed to braced. This could be due to the restriction of plantarflexion. Therefore, if the ability to jump is most critical to a certain basketball players game, then a stirrup brace may be optimal due to the lack of restriction in dorsiflexion and plantarflexion. In this study, the lace up brace resulted in the least impairment of performance overall. Therefore, if the athlete relies on all aspects of the game and their athletic ability to succeed, a lace up brace may be suggested for them. In summary, prophylactic ankle bracing is effective in reducing the incidence of injury with some performance cost, however, psychological perspective surrounding the brace, dynamic postural control, and single leg functional performance do improve throughout the season.

Conclusion

Prophylactic ankle bracing has been shown to reduce the incidence of acute ankle injuries in basketball players with no effect on severity. Preventative bracing is effective for athletes both with and without a history of ankle injury. Increased use of ankle bracing leads to a positive outlook towards bracing. The use of prophylactic ankle bracing is related to an improvement in some athletic functions but does involve some level of negative impact on performance. For athletes who are interested in the lowest overall impairment of performance, a lace up brace can be recommended. If vertical leaping ability is of utmost importance, a stirrup brace could be recommended.

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Assessing the Changing Impact of ACL Ruptures in the National Basketball Association from 1983 to 2018

Shivam Patel+, B.S., Parth Patel+, B.S., and Jacob Stibelman+, B.S.

+Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objective: To evaluate the change in peak player performance following acute injury of the ACL and determine if there has been improvement in functional outcomes that coincide with the advancements in anterior cruciate ligament repair since 1983.

Methods: Sixty-seven National Basketball Association players with anterior cruciate ligament injuries from the 1983-1984 to 2017-2018 seasons were included in the study. Changes in player efficiency rating before and after injury were evaluated and a linear regression analysis was performed.

Results: A positive trend line with a slope coefficient of 0.0995 was obtained via linear regression analysis. There has been a net 3.4825 improvement in peak player efficiency rating from 1983 to 2018.

Conclusion: As anterior cruciate ligament repair has advanced with time, the expected negative impact of an isolated ACL rupture on peak player performance has decreased.

Introduction

In the National Basketball Association (NBA), injuries can have devastating impacts on careers, teams, and communities. Professional organizations spend vast amounts of resources on medical staff for the prevention and management of injuries, but even so, players missed over five thousand games due to injury in 2018.[1] The average team spent over eighteen million dollars on salary alone for injured players that year. The average NBA career length is about 4.8 – 6.0 years according to statistical studies.[2] Ruptures of the anterior cruciate ligament (ACL) are particularly common and devastating, often sidelining a player for more than a year.[1]

Techniques for ACL reconstruction have evolved over the last fifty years.[3] Surgical repair was first conducted using the fascia lata, eventually replaced by fixation utilizing the patellar tendon.[4,5] Autograft repair with the hamstring tendon is common practice today, but this technique was not reported until 1983. The adoption of the technique and fixation methods have continued to evolve since then, and research on ACL reconstruction is ongoing at this time.[2]

The objective of this study is to evaluate the change in peak player performance following acute injury of the ACL and determine if there has been improvement in functional outcomes, such as back-to-play and player performance, that coincide with the advancements in ACL repair since 1983.

Background

The ACL is a fundamental stabilizer of the knee. It functions in tandem with the posterior cruciate ligament (PCL) to prevent excessive rotation and sagittal plane translation of the femur on the tibia. These stabilizing characteristics are critical for propulsion, changing directions, and stopping quickly.

The ACL limits anterior translation of the tibia on the femur while the PCL limits posterior translation. The mechanism of ligamentous injury is an extension of these properties.[6] Isolated PCL injury can occur when the tibia is met with posterior translational force from the dashboard in automobile accidents.[7]

The ACL can similarly sustain injury through excessive direct anterior translational force. However, in the high-performance athletic setting, ACL injuries most often occur without physical contact. During axial loading when landing, large ground reactive forces result in anterior translation of the tibia on the femur. The hamstring muscles engage to reduce the anterior translational force and reduce strain on the ACL.[8] As such, ACL tension and hamstring stiffness are inversely related.[9]

This balance is disrupted by the motions that occur in professional basketball. Movements such as quick pivots, balance shifts, and rapid deceleration prevent the hamstring muscles from contracting early enough to reduce the strain on the ACL.[8] As such, the ACL bears the excess load and is susceptible to injury. In the NBA, athletes are required to constantly jump, change directions, and change speed over the course of several miles.[10]

Between 25 to 50% of knee ligament injuries involve the ACL.[11] Spontaneous healing of the ACL is rare due to the lack of vasculature in the ligament, and as such, the gold standard of treatment as of 2018 is surgical autograft reconstruction sourced from the hamstrings or the patellar tendons.[12]

With these techniques, the tendon graft is fixated to the femur and the tibia to recreate the tension of the ligament. The hamstring technique was first reported in 1983 and has been shown to have fewer complications and less donor site morbidity than the patellar technique.[13,14]

Since its introduction, the hamstring technique has continued to evolve. Recent studies have shown that performing the reconstruction using a double bundle technique provides improved results in comparison to the originally described single bundle technique.[15] In this technique, two hamstring grafts are utilized to emulate the anatomic bundles of the ACL. The procedure is more technically challenging and requires additional fixation than the single bundle technique, but the potential benefit of anatomic reconstruction makes it a valuable proposition. Surgeon preference within the hamstring autograft procedure continues to change as research is ongoing to this day.[15]

Methods

Through review of the official NBA advanced statistics database, 83 players were found to have sustained acute ACL. Players were excluded from the study if they did not hold active status in the league when injured, did not return from the injury, or had more than one ACL rupture. Player Efficiency Rating (PER) was utilized to assess performance, and values were excluded if a player had not played in at least eight games that season. Included injuries were limited to those occurring between 1983 and 2018; the lower limit was set as the first reported ACL injury with available PER data, and the upper limit was set to allow for adequate time to collect data after players injured that year returned.

Player performance was determined using the metric PER, a measurement developed by columnist and statistician John Hollinger, designed to create a standard comparison of player performance across the history of the league. The statistic has been widely accepted as a measure of overall player performance and has been incorporated as a metric in the official NBA statistical database.[16] The formula for PER evaluates a player's in-game performance while adjusting for league pace, team pace, and minutes played.

PER data was obtained from the NBA Advanced Statistics database.[17] Qualifying seasons were defined as at least eight games or 10% of available games played. The peak PER value of a qualifying season before and after injury for each player was recorded and the numerical change was plotted for linear regression analysis. The resulting slope equation of the trend line was utilized to predict the impact of isolated ACL rupture at any given point in time.

Results

The linear regression line representing the change in peak PER before and after injury was found to have a positive slope of 0.0995 (Figure 1). As such, the negative impact of an acute ACL rupture was lessened with time; an injury in 1983 would decrease a player's PER after injury by 3.4825 more than an equivalent injury in 2018.

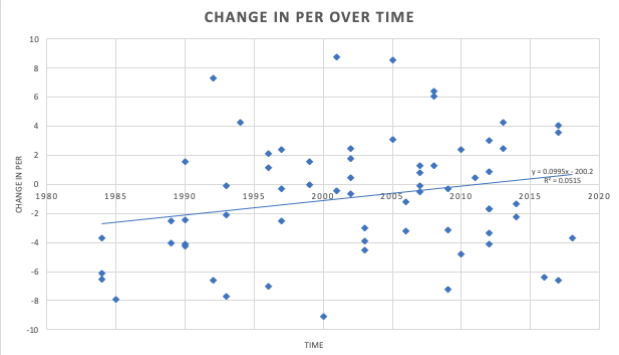

Figure 1: *Scatterplot of the change in peak PER after acute ACL injury. Each data point plots the change for one player against the year the injury occurred. The linear regression line runs from 1983 to 2018.*

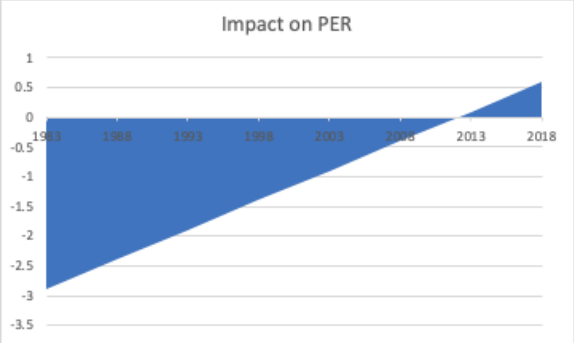

Figure 2*: Visualizing the change in PER over time impact using the linear regression line.*

The data points in this study were found to have considerable variability. Variance was calculated as 16.75. Standard deviation from neutral was found to be 4.09. R_2 was found to be .0515, and this variability can be visualized on the scatterplot.

Discussion

The improvement in performance impact when returning to the sport after acute ACL injury may be evidenced by the lessened impact on PER is depicted by the linear regression line. While the ACL rupture has historically been devastating to the careers of NBA players, the impact has lessened with time (Figure 2).

The lessened impact of injury correlates with advancements in ACL reconstruction technique. The patellar and hamstring techniques have historically shown success in restoring function, but in the physically demanding setting of the NBA, room for improvement will always exist. The development of the double bundle hamstring technique utilized today shows promise in being able to withstand the functional demands of the sport. The double bundle technique was originally described by Mott in 1983, and Tiamklang et al. report that the technique has been gradually adopted as arthroscopic knee surgery continues to advance.[15]

Several limitations were noted in this study. PER is the most comprehensive tool available for analyzing player performance at this time but the data can be skewed by various factors.[16] Because the metric describes performance per minute, it can be distorted by players who play very few minutes per game. An attempt to control outliers was made in this study by requiring players to have played in at least eight games or 10% of a given season for PER to be included, but some outliers still exist.

Additionally, PER data cannot account for a player's position in their personal career arc when the injury occurred. Players generally perform at their peak in the middle of their career, limited by experience initially and athletic ability later on. If a player is injured early in their career, their PER change may be falsely elevated due to the natural improvement that occurs with experience in the league. Conversely, a PER change following an injury late in a player's career may be excessively negative due to the natural regression that occurs with decreasing athletic ability accompanying age.

The study was also limited due to lack of control of external variables. Surgical repair technique, graft source, and the surgeon performing the repair was not controlled. Improvements in post-operative care and rehabilitation over time could also serve as a cofounding variable.

Finally, the study does not control for players with functional declines relating to external factors. External factors can include variables ranging from other injuries to personal life circumstances. A large sample size was utilized to offset this factor but no other controlling methods were utilized.

Conclusion

The ACL rupture has long been considered as one of the most devastating injuries a professional basketball player can incur. As research into improving ACL reconstruction continues, the trend of functional outcomes remains promising. The negative impact on peak player performance following acute ACL injury has markedly decreased since 1983 as reconstruction techniques have improved. Further research exploring player efficiency change based on surgical reconstruction technique would be beneficial in providing more information about the topic.

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Qualitative Study of Risk Factors, Injuries, and Preventative Measures in Rock Climbers

Katherine Hu[+], B.S. and Delphine Lam[+], B.S.

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objective: As rock climbing has become more popular, there have been some studies about related injuries, but few specific to the foot and ankle. This study identifies foot and ankle injuries, associated risks, and preventative measures in order for climbing gyms to improve their safety features and for clinicians to better adapt their treatment to climbing injuries.

Methods: The initial background research was done through the Journal of Foot and Ankle Surgery and Google Scholar. Study data was gathered with a survey and discussion in the form of focus groups. This data was then coded into categories based on the answers from the participants.

Results: A total of 31.8% of participants placed sprained ankles as the most commonly seen foot and ankle injury and 17.1% of participants named improper crash pad placement as the most likely risk factor. Taking off climbing shoes in between climbs, to allow the feet to rest in a more anatomical position, accounted for 50% of named preventative measures.

Conclusion: Using the information gathered from this study, climbing gyms can better understand what safety measures, such as safety pad placement, need improvement. Physicians can have a more comprehensive idea of what the most common foot and ankle injuries are in order to improve treatment for rock climbers. Health care providers should also be aware that sprained and broken ankles are the most common injuries experienced by rock climbers.

Introduction

In the past few years, rock climbing has gained popularity in Southern California as more indoor rock-climbing gyms have opened and more people have gained access to the sport. However, rock climbing has been a growing sport for years as people visit California for climbing destinations such as Joshua Tree National Park and Idyllwild. The sport has gained so much popularity, both locally and internationally, that in 2021 it will be featured in the Summer Olympics.

Rock climbing is an endurance and finesse sport with three major subcategories: bouldering, no ropes or harnesses, top rope, attached to rope above with belayer below, and lead climbing, attached to rope below with belayer below. Athletic footwear worn in all types of rock climbing should be tight, pointed, and hooked, providing more grip against the climbing surface. Often, rock climbing shoes are a few sizes smaller than the person's regular shoes. The shoes hold the foot in a supinated, stable position and the thinness of the sole provides more proprioception.[1] When the subtalar joint supinates, the less the midtarsal joint can move in pronation. This allows the forefoot to be stable on the rearfoot as a rigid lever.[2]

In a 2013 study by Buda et al., it was found that these qualities place the foot in a non-anatomical position, which can increase the risk of injuries such as recurrent ankle sprains.[3] Another study by Jensen and Watts (2008) tested joint angle changes for two-foot positions: pressure on the medial edge of the shoe at the first metatarsal and on the front of the shoe at the tip. They found that altering foot position changes the maximum angles of other joints and using toe positions creates a more vertical body position.[4] Activity consisting of repetitive, unnatural, or strenuous motions can make athletes more prone to injuries.[1] Other frequent injuries include contusions, calcaneus, talus, or ankle fractures, and ankle sprain.[5]

Currently in the literature, there are no studies exploring foot and ankle injuries associated with climbing from the perspective of the athletes. The purpose of this study is to understand the nature of injuries in relation to the climbing disciplines and to improve safety according to athlete recommendations. The insight from this study could potentially help both physicians and climbers to treat and minimize foot and ankle injuries.

Materials and Methods

Background information for this study was found by using key words such as "foot injuries in rock climbing," "rock climbing foot position," "rock climbing shoes," and "stretching injury prevention" in the Journal of Foot and Ankle Surgery and Google Scholar. Any articles not pertaining to these topics were excluded.

Participants were recruited from a climbing gym in Southern California during July 2019. All participants were at least 18 years old, rock climbed recreationally, and joined the study voluntarily. In total, 49 people participated, and one response was excluded because the participant was under 18 years of age. The research project was conducted with approval from the Institutional Review Board.

The survey, as seen in Figure 1, consisted of general questions such as gender, ethnicity, age, and climbing related questions with fill in the blank answers. Climbing specific questions included years climbing, participation in training, and the hours spent in each climbing discipline per week (bouldering, top rope, and/or lead climbing). Participants were also asked if they had experienced any foot and/or ankle injuries from climbing.

The optional discussion, seen in Figure 2, consisted of eight additional open-ended questions, where responses were recorded and transcribed. The questions included what participants observed to be the most common foot or ankle injuries in climbing and what risk factors were thought to contribute to these injuries. Participants were also asked what role climbing gyms have in reducing preventable injuries and whether they stretched or took any preventative measures. Additional questions regarding past foot and ankle injuries were included, such as impact of injuries on climbing and whether or not individuals sought treatment from a health professional. Participants with injuries who were treated by health professionals were asked how knowledgeable their healthcare providers were with rock climbing injuries

Survey for risk factors, lower extremity injuries, and preventative measures in recreational rock climbers

Please answer all the questions to the best of your ability. Accurate, detailed, complete answers will allow this study to be more effective. Thank you for your participation and time!

Demographic info
- Female
- Male
- Other: _____
- Prefer not to say

Ethnicity
- White
- Hispanic or Latino
- Black or African American
- Native American or American Indian
- Asian/ Pacific Islander
- Other:_____
- Prefer not to say

1. How old are you? _____
2. How long have you been rock climbing? _____
3. Have you had any training (taken a class, private lesson, etc.)?
4. How many hours a week do you spend:
    a. Bouldering _____
    b. Top rope climbing _____
    c. Lead climbing _____
5. Have you experienced any foot/ankle injuries of any kind? If yes, please explain what occurred:

Figure 1: *Survey participants filled out with general demographic and climbing information.*

Questions to ask during the focus group

1. Based on your observations and experience, what are some common foot injuries seen in rock climbing?
2. What do you think are some risk factors that cause these injuries to happen?
3. Have you had a foot/ankle injury? If you had to take some time off due to an injury, was your climbing ability negatively impacted?
4. If you did have a foot or ankle injury occur and went to a doctor, was the treatment beneficial to your health and rock climbing afterwards?
5. Do you think doctors should be more knowledgeable about treating rock climbing injuries?
6. Should climbing gyms offer more classes or mandatory training on safety measures/techniques to reduce the number of preventable injuries?
7. Do you stretch or warm-up before beginning climbing?
8. Do you do any preventative measures when at the gym (ex. Taking shoes off when not on the wall, if use more advanced shoes have a more comfortable pair to wear, stretch out toes after wearing shoes for a long period of time)?

Questions 3 and 4 only apply if participant has had a foot or ankle injury

Figure 2: *Optional discussion questions verbally answered and transcribed from participants.*

All data was recorded and transcribed after being collected from the survey and discussion. Identifying information was removed before analyzing the data. Two researchers listened to the recordings and answers were coded and grouped into categories. These categories were based on the survey answer choices and on similar responses for fill in the blank or discussion answers. Averages and standard deviations were calculated for each survey question where applicable. Categorical information was imputed into charts and graphs to demonstrate the result.

Results

The primary demographic of survey respondents was young adult, Caucasian males. As seen in Table 1, there was a variety in level of experience and about half of the people had training of some form. The number of hours per week spent in each of the climbing disciplines were fairly close in range, with bouldering and lead climbing practiced almost 3 hours per week and top rope climbing practiced about 2 hours per week. Most foot or ankle injuries were ankle sprains, although the majority of participants had no injuries.

Total participants	49
Gender	
male	65%
female	35%
Ethnicity	
Caucasian	47%
Asian/Pacific Islander	38%
Hispanic/Latino	13%
Prefer not to say	2%
Average age	33 +/- 9.4 yrs
Average # years climbing	5.5 +/- 6.5 yrs
Received training	
yes	51%
no	37%
learned from friend	4%
is an instructor	2%
no response	6%
Average hours a week spent	
bouldering	2.9 +/- 3.4 hr
top rope climbing	1.9 +/- 2.3 hr
lead climbing	2.8 +/- 4.3 hr
Foot injuries from climbing	
none	67%
sprained ankle	18%
toe from shoes	4%
broken foot	4%
other	7%

Table 1: *Participant demographics and survey information.*

Figure 3A shows the focus group discussion responses for the most common foot or ankle injury seen: sprained ankles. Other injuries seen less frequently, but with multiple responses, include fractured ankles, tibia or fibula fractures, and toenail injuries.

In Figure 3B, miscellaneous injuries included faulty rock mounts, slamming feet into the wall, climbing in the crack of the wall, inexperience falling properly, and wall inclination. The most significant risk factor for injuries was pad placement or quality.

As seen in Figure 4, many participants mentioned that hosting additional training classes at rock climbing gyms could be beneficial in reducing preventable injuries. The majority of people also performed stretches or warm up exercises before they began to climb. The most common preventative measure participants performed was taking off shoes in between climbs. Some people also have multiple pairs of shoes, so that their shoe matches the difficulty of the climb.

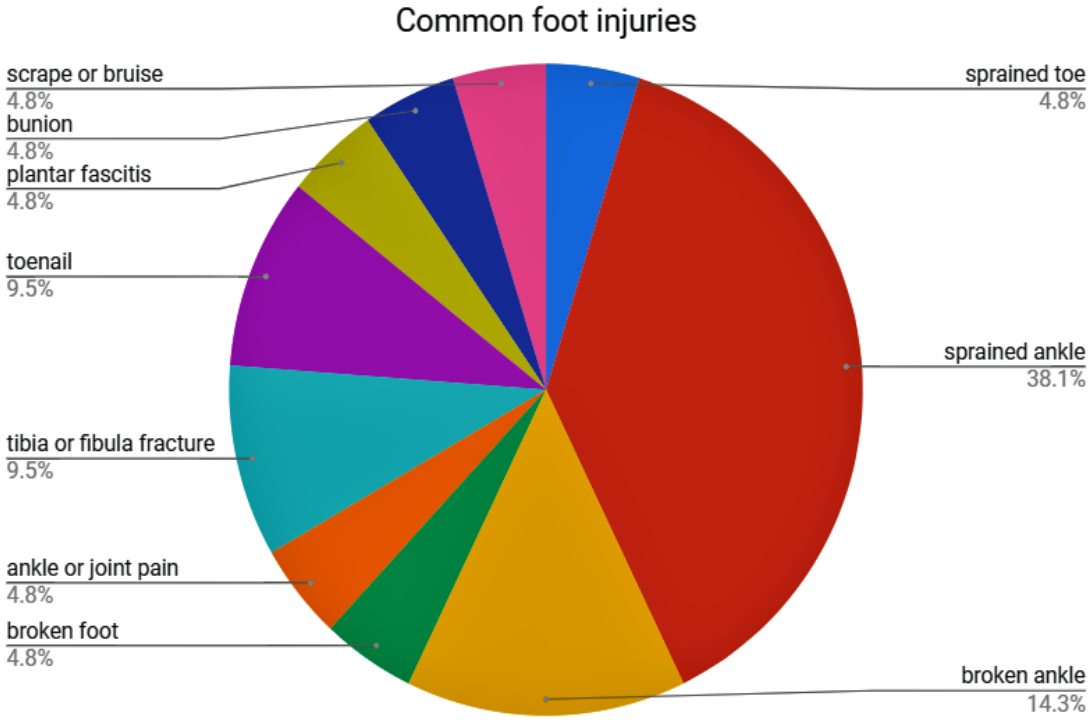

Figure 3A: *Responses from participants about injuries seen from climbing.*

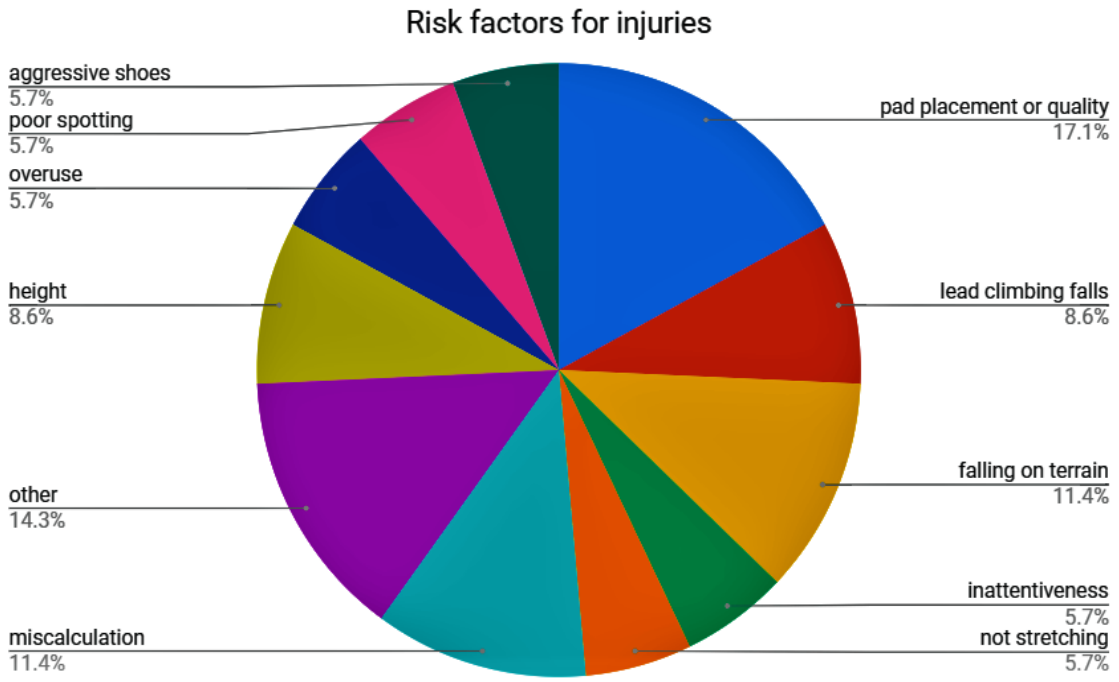

Figure 3B: *Responses from participants about risk factors that cause injuries to occur.*

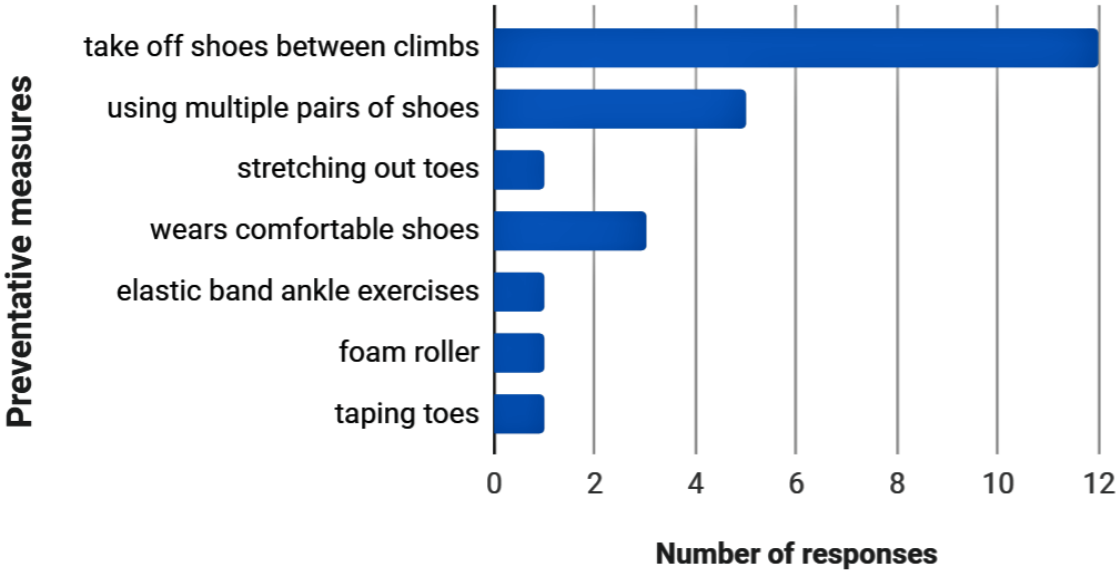

Figure 4: *Various preventative strategies performed by participants.*

Discussion

Foot and ankle injuries are not the most prevalent health issue in climbing, however, these types of injuries still pose issues to climber ability and quality of life. Only one of the preventative measures noted by participants directly relates to the ankle. The other responses for preventable measures practiced indicates many climbers emphasize preventing toe and foot injuries over ankle injuries. This may occur because the toe and foot discomfort from the shoes is more evident compared to ankle injuries, which can be chronic issues.[1,4]

Ankle injuries can result from overuse, but also from accidents, where climbers can do little to prepare their ankle for such an event if the landing space is unsafe. A fall with a person or obstacle in the way, improperly aligned landing mats, and worn out equipment are some examples of hazardous landing zones that the climber cannot always control. Previous studies by Buda et. al (2013), Schöffl and

Küpper (2013), and Killian, Nishimoto, and Page (1998) found similar patterns in types of injury. These studies have noted that the design of the shoe can help climbers by providing a biomechanical advantage, but in doing so also increases the risk of ankle sprains.[2,3,5] The shoes exhibit a paradox because they provide more security when climbing but increase risk when falling and overall are uncomfortable.

Since the majority of foot or ankle injuries seen were sprained or fractured ankles and the most commonly cited risk factor is pad placement, this may suggest that inappropriate pad placement may result in falling incorrectly and injuring that ankle. The foot can become trapped when landing in between pads after falling from a height of up to 15 feet. Further insult comes from climbing shoes which hold the foot in a non-anatomical position, causing the foot to twist as it is trapped in between the pads.

Removing the shoes when not actively climbing and improving landing pads may be the best option to reduce ankle injuries. The study conducted by Buda et. al (2013) also evaluated how climbing footwear itself may be the most common cause of foot and injuries. Climbing shoes are usually a few sizes smaller than normal footwear causing the foot to be squeezed into a laterally stable supinated position. Out of its 144 participants, the only statistically significant correlation between ankle injuries and small shoe size was recurrent ankle sprains.[3]

It has been suggested that there are benefits to stretching in sports that require a compliant muscle-tendon unit, such as climbing.[6] However, other studies have found that there was not a significant reduction in injuries, but some reduction in soreness.[7,8] Some of the participants in this study noted that they stretch before climbing, but in their opinion, it was not a major factor for injury prevention. Overall, there is inconclusive evidence from previous studies and this study to determine whether stretching is actually beneficial in climbing.

One main limitation of our study is that the sample size consisted of only 49 participants and all were from the same climbing gym. More participants from multiple gyms would provide diverse responses that more accurately represent the population. This could be a possible research idea for future studies to expand on this topic. Another limitation is that we conducted our study on a few days of the week. Collecting over weeks or months may have yielded more diverse responses. The study may also contain bias since only two people transcribed and categorized the data. Future studies can reduce bias by having more than two people transcribe data. It is also likely that there was participant bias in favor of stronger opinions since participation was voluntary.

Conclusion

In order to prevent foot and ankle injuries, training classes could be implemented by climbing gyms or expanded to include further safety instructions for appropriate pad placement and falling techniques. Removing shoes when not actively climbing allows toes and feet to rest in a more anatomical position which can be a simple measure that climbers can utilize if they have pain from tight shoes. The results from this study in conjunction with future research may provide more insight into this sport and the best way to care for the athletes. Obtaining a larger sample size can also improve accuracy of data and results.

Acknowledgements

We would like to thank the Western University of Health Sciences, Research Committee and the Office of Research and Biotechnology for allowing us to create this project through the Summer Student Fellowship Grant. We also want to thank Wesley Shih of Sender One Climbing for his permission and guidance collecting data at the gym.

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Advancements of Hallux Valgus Treatment Methods

Kevin Trinh+, M.B.S., Mckenon Abreu+, B.S., and Derek Jackson+, B.S.

+Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objective: In the field of podiatric medicine, there have been many different methods of treating hallux valgus, most of which involve surgical correction, but as the field progresses, surgical techniques continue to evolve as well. The objective of this article is to present a review of current literature on the advances in treatment methods for hallux valgus.

Methods: A literature search was done on PubMed and Google Scholar in order to retrieve several articles discussing modern treatments of hallux valgus as well as the efficacy of these treatments. Thirty articles were reviewed, and ten articles were found to be appropriate for this study. The Pubmed and Google Scholar databases were utilized with search keywords such as "hallux valgus," "treatments," "advances," and "bunion," and any articles published prior to the year 2000 were excluded.

Results: In the juvenile procedures, the average hallux valgus angle changed from 26.5° preoperatively to 20.2° and the intermetatarsal angle changed from 14.1° to 10.5°. In the SERI osteotomy procedures, the mean hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal articular angle (DMAA) were significantly decreased and normalized in 20 patients, 25 patients, and 4 patients, respectively. With the Reverdin-Isham technique, the fixation group showed a three-degree indication of superiority for the MTP angle compared to the non-fixated standard. In the study regarding magnesium biodegradable screws, the results showed that the magnesium screws were nearly as effective as the standard titanium screws.

Conclusion: Modern treatment methods for hallux valgus are still centered around surgery due to its high success rate. Research should continue to be conducted in the field of podiatric medicine in order to perfect the way we surgically correct bunions or possibly discover a way to fix these deformities without surgery altogether.

Introduction

Hallux valgus is a term used to describe when the hallux, or great toe, deviates towards the lateral side of the foot, and the first metatarsal head deviates towards the medial side of the foot.[1] This condition has been shown to have a negative impact on patient quality of life and is typically associated with foot pain, impaired gait patterns, poor balance, as well as an increased risk of falls among the elderly.[2] Historically, in order to treat hallux valgus, surgical intervention has been one of the most commonly used and successful methods due to longer symptom relief.[2]

In terms of the etiology of hallux valgus, there can be several different causes. For example, the wearing of constricting shoes can play a factor in hallux valgus development. Genetic predisposition is another major factor, with up to 68% of patients showing a familial tendency.[3] Pes planus, or flat feet, is yet another factor in the progression of hallux valgus deformity, and hypermobility of the first tarsometatarsal joint has also been considered a cause of hallux valgus. Each of these causes requires a surgeon to consider different treatment methods.[3]

Although more conservative treatments for hallux valgus can be done with the use of accommodative footwear, there is not much evidence to prove the efficacy of this method in the long term as symptoms tend to be relieved for only about six months or so.[3] There is also no evidence to show that accommodative footwear even prevents the development of hallux valgus. Surgical treatment, however, is performed when pain, present on the bunion itself or in the second metatarsophalangeal joint, is not relieved through more conservative methods.[3]

When planning a bunion corrective surgery, surgeons have over 130 different techniques to choose from.[3] Surgical techniques can range from MTPJ, distal metatarsal, mid-shaft, and metatarsal base corrections and many surgeons use a combination of techniques. The wide variety of techniques indicates that no single method is perfect, and each case may require different or even multiple techniques.[3] In recent years, a number of new techniques have surfaced, and determining which technique to use can be difficult. In order to choose the proper technique, surgeons must consider which category the bunion falls under.[3] Classifications of hallux valgus include mild hallux valgus, moderate hallux valgus, severe hallux valgus, hallux valgus with first tarsometatarsal hypermobility, hallux valgus with first metatarsophalangeal joint degeneration, and hallux valgus interphalangeus. Depending on the type of hallux valgus present in a patient, surgeons may prefer to use one technique over another.[3]

Although there are a variety of methods used to treat hallux valgus, the field of medicine is constantly changing, and new methods are being developed. It is important for these advancements to occur so that physicians can continue to provide the best possible care for each individual person. This article aims to identify these new advancements in treatments as well as show the efficacy of these methods, which include epiphysiodesis, minimally invasive surgery, and biodegradable hardware.

Methods

A search of articles relating to advances in hallux valgus treatment was conducted using Pubmed and Google Scholar. The Pubmed and Google Scholar databases were utilized with the following search keywords: "hallux valgus," "treatments," "advances," and "bunion." Any articles published prior to the year 2000 were excluded. Articles were chosen if they presented a new (defined by the year 2000 or later) or different method in treating hallux valgus deformities.

Results

Juvenile Hallux Valgus

Hallux valgus among juveniles during the growth stage is a rare but concerning deformity. When the symptoms and deformity worsen or begin to cause psychological or physical pain, surgery should be considered but is not recommended until the juvenile has reached maturity and the bone plates have closed. One new treatment that is proving successful in juveniles for this problem is the temporary screw epiphysiodesis of the lateral epiphyseal plate of the first metatarsal.[4]

The procedure performed on 22 patients in the 2018 study by Schlickewei et al. involved a 1-cm long longitudinal skin incision made just distal to the proximal epiphyseal plate and outer cortex of the first ray metatarsal. On average the screw was left in the patients for 27.8 months with an average patient age of 11.1 years at time of insertion. At the time of the follow-up, six patients had been fully corrected and the screws were removed. The preoperative average hallux valgus angle (HVA) was 26.5° and at time of follow up was 20.2°. The preoperative average intermetatarsal angle (IMA) was 14.1° and at time of follow up was 10.5°.

Figure 1: *Plain standing radiograph of the right foot of an 11-year old girl with juvenile hallux valgus deformity: (A) preoperative; (B) 13 months after screw epiphyseodesis.*[4]

Simple, Effective, Rapid and Inexpensive Osteotomy for Correction of Hallux Valgus

SERI osteotomy, also known as a Bosch osteotomy, is an intriguing procedure due to the fact that it is minimally invasive, involves less tissue dissection and requires the patient to wear minimal hardware in order to heal. A variety of instruments can be used thus making it a cheap and easily adopted method. SERI can also be performed without fluoroscopy.[5] With SERI osteotomy procedures most patients can be sent home the same day of surgery.[6] The average operation time is 11.1 minutes and multiple studies have found this procedure to be cost effective with one study reporting the opposite.[6] The study from 2014 by Poggio et al. compared not only the actual cost of the procedure, which is found to be cheaper, but also the total cost of follow up visits due to an increase in postoperative complications found with the SERI procedures made it more expensive than the compared scarf procedure.[7] These complications, which caused the overall cost for patients undergoing SERI operations to increase, were not seen in many other studies. The patients observed in the 2019 study by Almalki et al. had radiographically measured hallux valgus angles that were significantly improved one year after the surgery, no complications developed during the 1-

year follow-up period, and there was no recurrence as seen in Table 1.[6] Preoperatively, on average between all the patients in this study, the hallux valgus angle was 33.7°. The intermetatarsal angle was 12.9°, and the distal metatarsal articular angle was 29.1°. 25 patients had subluxed 1st MTP joints, and 29 patients had subluxed sesamoids. Postoperatively, the hallux valgus angle decreased to 12.2°. The intermetatarsal angle decreased to 5.7°, and the distal metatarsal articular angle decreased to 21.5°. Only 12 patients had subluxed 1st MTP joints and 13 had subluxed sesamoids.[6]

	Preoperative *n* (%)	Postoperative *n* (%)
Congruency of the 1st MTP joint		
Congruent	4 (13.8%)	17 (58.6%)
Subluxed	25 (86.2%)	12 (41.4%)
HVA	33.7 (8.3)	12.2 (8.4)
IMA	12.9 (3.2)	5.7 (2.2)
DMAA	29.1 (17.3)	21.5 (1.5)
Regnauld classification		
1.0	29 (100%)	26 (89.7%)
2.0	–	3 (10.3%)
Sesamoids		
Subluxed	29 (100%)	13 (44.8%)
Not subluxed	–	16 (55.2%)

Mean ± SD values or number (%) of patients are shown
*p values < 0.05 were considered significant
Abbreviations: *MTP* metatarsophalangeal, *HVA* hallux valgus angle, *IMA* intermetatarsal angle, *DMAA* distal metatarsal articular angle

Table 1: *Preoperative and 1-year postoperative radiographic average measurements of the 29 patients.*[6]

Reverdin-Isham Technique

The Reverdin-Isham technique is a minimally invasive percutaneous surgical technique for hallux valgus treatment. This technique originally does not use any osteosynthesis to fixate the realigned first ray. The goal of the 2018 study by Sato et al. is to compare the original Reverdin-Isham technique to a version of this technique with added osteosynthesis with cannulated screws.[8]

The study used 22 feet across 15 patients with hallux valgus and divided them into two groups of 11. In step one of this procedure, the dorsomedial eminence of the first metatarsal head was resected up to the articular surface of the head of the first metatarsus. This was performed with a percutaneous wedge burr under fluoroscopic guidance. During step two, using straight Shannon burrs, an osteotomy was performed on the first metatarsal, parallel to the articular surface. The hallux was forced into adduction, correcting the MTP angle. In step three, the Akin procedure was performed and through a third access with a high-torque straight burr, where no fixation was performed. In both groups, the surgery was the same until after the third step. After the third step, fixation was used in the study group three directions using cannulated screws, while no fixation occurred in the control group. Both groups were dressed and bandaged in hypercorrection, which was maintained for five weeks and six weeks after surgery conventional footwear was allowed.[8]

A total of 22 feet went through the Reverdin-Isham osteotomy with a fixated study group of 11 and a non-fixated control group of 11. The akin procedure was only used in eight cases, four with fixation and four without. For both groups, the MTP angle indicated a significant difference between preoperative and postoperative evaluation with a p-value less than 0.001.[8]

Figure 2: *Reverdin-Isham, without fixation (left) and postoperative radiograph with cannulated screw fixation (right).*[8]

For the fixated and non-fixated groups, both had a p-value of $p < 0.001$ to show a significant difference between the pre- and postoperative evaluations. However, for the group using fixation, there was a three-degree indication of superiority for the MTP angle observed when compared to the group without. There was no statistical difference between the Akins fixation group and the non-fixated group. The Reverdin-Isham osteotomy improved the condition of patients in both groups.[8]

Magnesium Biodegradable and Titanium Compression Screws

Hardware is used in surgery to help mend broken or abnormal bone deformities but is often removed for various reasons. Orthopedic hardware is typically constructed from titanium, steel, and other non-absorbable metals. This is problematic as it causes an increased chance of infection, scar tissue build-up, and it complicates the use of MRIs and other imaging modalities. These risks can be decreased if, instead of the titanium and steel surgical

implants, a biodegradable magnesium-based screw was used.[9]

The magnesium-based screws are lower than titanium on the Young's modulus, a mechanical property that divides the stress by the strain to determine the stiffness of a material. Because the Young's modulus of magnesium is lower, the stiffness is therefore also lower. This makes the screw at a level that is closer to the Young's modulus of bone, while still allowing the magnesium metal to hold stability as a screw.[9] However, there were no significant differences on the basis of tensile testing between the magnesium and titanium screws.[10] The biodegradation of magnesium occurs through corrosion, reducing the inflammatory response, and minimizing osteolysis.[9] Over a period of time and depending on the type of magnesium screw, the magnesium screw is reabsorbed and replaced by bone and biologically inert potassium crystals, which do not affect bone formation.[9]

A 2019 study by Atkinson et al. follows the procedure of hallux valgus deformity, with 11 patients undergoing corrective surgery with the magnesium biodegradable compression screw, and a control of 25 patients using standard titanium screws. This was performed at the same center and by the same physician as to minimize variation in surgical technique.[9]

The mean operating time of magnesium was 35 minutes compared to the titanium being 34 minutes. Overall, the MOXFQ score parameters for walking/standing, foot pain, and social interaction, as well as the FAOI scale, showed a P-value of 0.004 for the magnesium and 0.001 in the titanium patient cohorts. No patients from either group needed revision surgery or surgery to remove hardware. At six weeks post-op, other than magnesium being less radiopaque than titanium upon radiological assessment, no migration or loosening of the screws were detected in either case. For both groups, similar patterns were observed, and both showed social interaction and foot pain to improve significantly following surgery.[9]

In the case of hallux valgus, there were no vast differences between subjects who received the magnesium biodegradable magnesium compression screw and the subjects who received the titanium compression screw. This study shows that the magnesium screw is clinically effective, with the added benefit of not needing hardware removal.[9]

Discussion

Most of the studies consisted of fairly small cohorts ranging from ten to thirty participants. Despite the small sample sizes, many of the advancements had positive results. In the future, additional studies with a larger sample size would be beneficial in order to provide more accurate results. Furthermore, even though there are many methods available for treating hallux valgus deformities, it is important for research to continue to be conducted in order to find the best methods and modalities when treating patients. For this reason, the main advancements seen in treating bunions are by way of modifying and implementing new surgery techniques as well as the development of new tools and hardware.

In the study by Almalki et al. in 2019, where the SERI osteotomy was performed, the resulting overall average of the various angles seen decreased significantly. The hallux valgus angle (HVA), which is the angle between the longitudinal axes of the proximal phalanx and the first metatarsal bone of the big toe, decreased by 64%. The intermetatarsal angle (IMA), which is the angle measured between the first and second metatarsal shaft on an axial view of the foot, decreased by 56%. The distal metatarsal articular angle (DMAA), which is the angle between the perpendicular line of the first metatarsal longitudinal axis and the line through the base of the distal articular cap of the first metatarsal, decreased by 26%.[6]

The 2018 study by Sato et al. of the Reverdin-Isham technique tried to evaluate if fixation would be able to improve the surgical technique that was previously done without fixation. Though this study was not able to present any significant difference between the technique with and without fixation, it states the need for further studies to be more conclusive. If the results for fixation and without fixation are similar after further research, then it would be reasonable to continue without fixation so that there is a decreased chance of hardware complications.[8]

Magnesium screws show a lot of potential for future clinical applications. Since they are biodegradable and eventually turn into bone, they eliminate the need for future hardware removal. The concept of biodegradable magnesium screws appears to be useful in many different surgical procedures as two different articles, by Atkinson et al.[9] and Wang et al.[10], cover both bone fixations and ligament repairs. As for their specific use in hallux valgus treatments, further research will need to be conducted.

Surgeries for hallux valgus are performed often, but more compilation studies need to be done in order to better compare the data. This will allow researchers and podiatric surgeons to have a better understanding about which procedure produces the best results. This research could also include a cost analysis section showing the cost of surgery as well

as the cost of supplemental visits to the doctor until the bunion is completely resolved.

Conclusion

Current advancements in treating hallux valgus still revolve around surgical intervention due to its greater success in correcting the deformity compared to non-surgical techniques. The results showed the various techniques and modifications to be effective, but future research should be conducted with larger sample sizes and a wider array of procedures. Although the new techniques described in this article are not necessarily better than previous techniques, they do add to the multitude of techniques already available so that surgeons can better decide whether or not to perform a certain technique based on the classification of the hallux valgus deformity. In addition, these advancements show that surgical techniques are constantly being added and improved, thus progressing the field of podiatric medicine and surgery.

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Reliability Assessment of Limb Length Discrepancy Measurement from ASIS to Medial Malleolus

Branda Bui [+], B.S., Jacob Stibelman [+], B.A., and Arnold Ross[+], DPM

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objective: To study the reliability of a leg length discrepancy measurement from the anterior superior iliac spine to the medial malleolus.

Methods: Thirty randomly selected volunteers measured the leg length discrepancy of three subjects. They were grouped into three groups of ten volunteers, and each group was randomly assigned a subject to measure. Each volunteer measured their subject three times, and the averages were calculated. Intraclass correlation coefficients were used to assess the reliability of the measurement technique.

Results: Intraclass correlation coefficients for inter-rater reliability showed a negative or near negative values indicating a wide distribution of measurements while the distribution of intra-rater reliability were 0.412, 0.654, and 0.649 suggesting a narrow distribution.

Conclusion: The anterior superior iliac spine to medial malleolus measurement technique is not a reliable method to diagnose leg length discrepancies.

Introduction

Small limb length discrepancies (LLD) are common and usually asymptomatic simply due to variation between the right and left sides of the body, However, some leg length discrepancies lead to back pain and abnormal developments in gait and posture.[1] There are many corrections and treatments for LLD that range from conservative to surgical. Though the severity of the LLD plays a major role in determining the best treatment, an equally important factor is the type of LLD a patient is presenting with: either anatomical or functional LLD. Anatomical LLD occurs when a unilateral physical shortening exists between the head of the femur and the ankle mortise of the lower limb. Conversely, functional LLD is characterized by alterations in the mechanics of the hips, knees, ankle, and foot. Other ways functional LLD can arise are adaptive shortening of soft tissues, ligamentous laxity, and axial malalignments.[2]

One of the main consequences of this anatomical inequality is pelvic torsion. In a 2005 study by Knutson that used foot lifts to examine the relationship between pelvic torsion severity and leg length inequality, there was an approximately linear increase in pelvic torsion as the leg length difference was increased from 2/8 to 7/8 inch.[3] The study concludes that multiple problems could arise from LLD depending on the level of pelvic obliquity in the frontal plane. Possible conditions include functional scoliosis, posture deformation, and gait abnormalities, all of which affect a patient's function and quality of life.[1]

The two primary techniques for measuring leg length discrepancy are manual measurement and radiographic imaging.[2] Our study focused on measurements taken from the ASIS to the medial malleolus, but other options include the ASIS to lateral malleolus, umbilicus to medial or lateral malleolus, and PSIS to medial or lateral malleolus. These methods are commonly used in clinics due to how easily accessible and inexpensive they are. Alternatively, LLD can be measured radiographically by using a scanogram. A scanogram is a type of x-ray examination that is taken when a more objective measurement is required. A scanogram is done by having a patient lie supine, and the device will shoot three views. The x-rays put the three views together in order from proximal to distal: hips, knees and ankles. Overall this method is non-ideal for assessing patients on a regular basis due to increases in time, cost, and radiation exposure of the patient.[4]

The current literature is limited in assessing the reliability of currently used LLD measurement techniques. For this reason, an investigation into the reliability of the ASIS to medial malleolus method is warranted due to its widespread use. The aim of our study is to provide preliminary data to test the reliability of this commonly used technique. Determining reliably is important to ensure clinicians are making the right diagnosis.

Methods

Thirty randomly chosen volunteers measured the LLD on three random subjects. The thirty volunteers were divided into three groups of ten, and each group was assigned one random subject. The thirty volunteers were a mix of podiatry students and other health professions students, all ranging from 22 to 56 years old. Prior to any measurements being taken, all volunteers were

briefed on how to measure from the ASIS to the medial malleoli. Measurements were done one at a time in a controlled environment to avoid volunteers from influencing one another's measurements. Each volunteer used a tape measure to measure the subject once on each leg from the ASIS to the medial malleoli. Each volunteer measured their subject three times to control for external factors and natural variations that may have compromised the volunteer's initial evaluation.

After these 90 data points were collected, the software SPSS was used to generate intraclass correlation coefficients for an inter-rater and intra-rater reliability assessment. Intraclass correlation coefficients (ICC) were used to assess the reliability of the measurement technique. Based on the 95% confidence interval of the ICC estimate, values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 are indicative of poor, moderate, good, and excellent reliability, respectively.[6]

Results

Two types of intraclass correlation coefficients were generated, intra-rater reliability and inter-rater reliability. Intra-rater reliability compares each repeated measurement to one another by the same rater, while inter-rater reliability compares the values between each rater. When looking at single measurements, the intraclass correlation coefficients (ICC) for intra-rater reliability were 0.412, 0.654, and 0.649 while the inter-rater reliability ICCs were –0.026, -0.004, and 0.022. Only the intra-rater reliability ICCs were statistically significant.

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.412[a]	.017	.779	3.016	9	18	.022
Average Measures	.678	.051	.913	3.016	9	18	.022

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	-.026[a]	-.058	.564	.574	2	18	.573
Average Measures	-.341	-1.195	.928	.574	2	18	.573

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.654[a]	.316	.886	7.057	9	18	.000
Average Measures	.850	.581	.959	7.057	9	18	.000

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.022[a]	-.021	.682	1.664	2	18	.217
Average Measures	.180	-.252	.955	1.664	2	18	.217

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.649[a]	.302	.885	6.497	9	18	.000
Average Measures	.847	.565	.958	6.497	9	18	.000

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	-.004[a]	-.030	.548	.895	2	18	.426
Average Measures	-.038	-.402	.924	.895	2	18	.426

Figure 1*: Intrarater and Interrater Reliability of Subjects 1, 2, and 3, respectively.*

Discussion

Our primary aim was to study the reliability of an LLD measurement from the ASIS to the medial malleolus. It was up to each volunteer to decide how to most accurately measure the subject (i.e. measuring to the distal vs. proximal medial malleolus). Variation was allowed in order to emulate the subtle differences between clinicians using the same measuring method. Based on the 95% confidence interval of the ICC estimate, values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 are indicative of poor, moderate, good, and excellent reliability, respectively.[6] As seen in Figure 1, the intrarater reliability ICCs were 0.412, 0.654, and 0.649, all with a p-value of less than .05. However, all the interrater ICCs were negative or near negative values. This suggests a single person measuring from the ASIS to the medial malleolus could reliably achieve the same measurement, while reliability decreases when compared across multiple raters leading to a wide range of measurements. Furthermore, the use of podiatry students in the volunteer population was likely not a confounding variable in the study since the volunteers only needed to know two anatomical locations - the ASIS and medial malleolus - and was therefore easily taught to volunteers that were non-podiatry students.

Observations that were made during the experiment were that each rater had a different way of taking the measurement. Some chose the proximal or distal aspect of the medial malleolus, while others approximated between values. These variations and lack of standardization may have played a large role in the wide range of values recorded across all raters.

Ideally, as long as the measurer is consistent in his individual technique between leg length measurements the calculated LLD should remain consistent across measurers despite using a slightly different technique. Therefore, we can conclude that the measurers were not careful with their consistency between leg measurements. One other scenario is possible. Perhaps, it is simply a difficult task to maintain consistency measuring such small differences in leg lengths, and therefore the differences observed between measurers are normal human error. Either way, if consistency between legs is difficult to obtain then perhaps one is better off using a scanogram for a more accurate LLD measurement. One other advantage to the scanogram method is that it is capable of measuring from the ASIS to the bottom of the heel. The ASIS to medial malleolus measurement technique discounts the LLDs that can occur below the point of the malleolus, such as heel atrophy. However, besides cost and exposure to radiation a disadvantage of the

scanogram is it is considered an indirect measurement while the ASIS to medial malleolus is a direct measure. Ultimately, more research needs to be done on the reliability of currently used LLD techniques since the current literature is limited, and perhaps the development of novel measurement techniques should be considered.

Conclusion

Measuring LLD from the ASIS to medial malleolus remains a commonly used method because of the convenience and simplicity. Using a measurement method with such wide variation leads to inaccurate results that may under or overestimate the severity of a patient's deformity. Interpretation of this data therefore suggests this measurement method is overall not reliable, due to the large variation in measurements as the number of raters was increased. Standardizing the exact method of taking manual measurements could eliminate this wide range of values. While there are certainly statistical differences among each individuals' measurements, these differences may or may not be clinically significant. Further research needs to be done on the correlation of the degree of LLDs and associated symptoms. For the time being, due to its convenience and widespread use, ASIS to medial malleolus remains a commonly used measure of leg length discrepancy.

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Surgical Treatment of Lisfranc Injuries Through Open Reduction with Internal Fixation and Primary Arthrodesis: A Current Review

Alex Barney[+], B.S., Alex Dang[+], B.S., Nathan Fischer, [+] B.A., and Anthony Wright[+], B.S.

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT:

Objective: To review the current literature on the two main Lisfranc injury treatments, open reduction with internal fixation and primary arthrodesis.

Methods: Relevant research articles for open reduction internal fixation, primary arthrodesis, and Lisfranc injury were found via the Journal of American Foot and Ankle Society, Journal of Bone and Joint Surgery, PubMed, and National Institute of Health databases. Twelve articles were analyzed and included in this review.

Results: Multiple studies revealed small sample sizes that reported miniscule statistical difference between the treatment modalities. The group of patients who received PA treatment in Cochran et al had an 87.4 Foot and Ankle Ability Measure score (FAAM) and were able to return to duty after an average of 138 days. The ORIF group had an 83.3 Foot and Ankle Ability Measure score (FAAM) score and had an average of 209 days before returning to duty. Hawkinson et al. study showed 80% return to duty rate with primary arthrodesis (PA) and 65% return to duty rate for open reduction internal fixation (ORIF). Henning et al. study showed 16.7% of total patients required revision surgeries under primary arthrodesis (PA), while 78.6% for open reduction internal fixation (ORIF). Finally, Ly et al. study had 86.9% on AOFAS score and 71.4% returned to full physical activity.

Conclusion: The current literature is split as to which method of treatment is best to treat Lisfranc fractures. Yet, the most current analysis done by Han et al. has shown that despite the unavoidable heterogeneity of the data available, primary arthrodesis was a better procedure compared to open reduction internal fixation. Data reveals a faster return to duty rate, a better fitness score, a lower implant removal rate, a lower rate of complication, and a higher American Orthopedic Foot and Ankle Society score.

Introduction

The Lisfranc ligament supports the transverse arch of the foot and connects the lateral side of the first cuneiform to the medial side of the second metatarsal on the plantar side of the foot.[1] An injury to the ligament affects the tarsometatarsal (TMT), intercuneiform, and the naviculocuneiform joints. The Lisfranc injury accounts for 0.2% of all fractures and occurs 2-4 times more in males than females.[1,2] The average patient with a Lisfranc injury is in their thirties.[3]

Around 20% of Lisfranc injuries are missed and can cause decreased midfoot stability.[4,5] If not treated correctly, the injury can lead to severe arthritis, chronic pain, and impact overall foot function.[4] Severe and minor trauma such as motor vehicle accidents, are more common than minor impact injuries, such as falling from a moderate height, and have been shown to cause Lisfranc.[2] Patients complaining of midfoot pain and overall loss of midfoot support should be evaluated for a Lisfranc injury. Physical examination shows a tender and swollen midfoot along with ecchymosis of the medial plantar arch. Unilateral injuries are more common, but bilateral injuries can occur. Therefore, it is crucial to compare both feet. Another physical finding is the "gap sign" between the first and second metatarsals (Figure 1). Other physical findings include pain upon abduction and plantarflexion of the midfoot while stabilizing the rearfoot. Other radiographic findings include the "fleck sign" which can be especially helpful as diastasis between the base of the first and second metatarsals is seen in up to 90% of patients.[6,7] Once a Lisfranc injury has been identified, it is crucial to classify the type of injury present to allow the surgeon to choose the best treatment option for their patient.[7]

Several current classification systems exist for Lisfranc injury. The Myerson classification system is based on dividing the injury into categories based on midfoot joint articulations. Nunley and Vertullo's classification of Lisfranc injury, used more for low impact injuries, is mainly based on weight-bearing radiographs and the classification used in this study. Based on Nunely and Vertullo's classification an anterior-posterior radiographic view shows no displacement and resolves on its own through conservative treatment for a stage I injury. The patient is unable to bear weight on the affected foot, along with the restricted motion of the midfoot. The radiograph shows a diastasis of 1-5 mm, but the lateral view shows a midfoot arch still intact. A diastasis greater than 5 mm indicates a stage III injury, and the midfoot arch is reduced. Stages II and III require anatomical reduction (Figure 1).

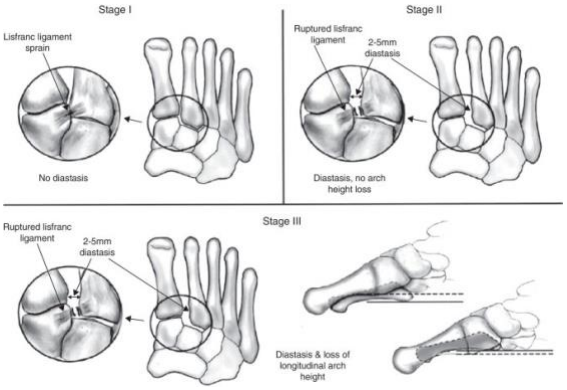

Figure 1: *Radiograph of different stages of Lisfranc injuries adapted from Knee Surgery Sports Traumatol Arthroscopy.*[2]

Whether the injury is strictly ligamentous or osseous-ligamentous, determines the procedure chosen.[5] Certain studies have concluded that open reduction with internal fixation (ORIF) and primary arthrodesis (PA) show similar results and are the most preferred surgical treatments for Lisfranc injuries.[5] However, a discrepancy exists between the efficiency and functionality of the two treatments.[5] Open reduction is a frequently used method for treating Lisfranc injuries.[1] As a frequent method shown to treat Lisfranc injuries ORIF is shown to produce acceptable results for osseous-ligamentous fractures. However, studies have suggested that PA provides better functionality in strictly ligamentous injuries.[1] PA can also be also used for unstable injuries because it prevents painful post-surgery arthritis and decreases the need for future surgeries.[8] The purpose of our study is to compare the treatment results and functionality of ORIF and PA in the treatment of Lisfranc injuries.

Methods

Twelve relevant research articles for ORIF and PA for Lisfranc injury from 2006-2018 were identified via the Journal of American Foot and Ankle Society, Journal of Bone and Joint Surgery, PubMed, and National Institute of Health databases. Inclusion criteria included patients that were adults with Lisfranc injuries, surgical treatment with PA or ORIF, post-op outcome assessment with American Orthopedic Foot and Ankle Society (AOFAS), and Visual Analog Scale (VAS) scores, retrospective study, prospective randomized study, and meta-analysis. Exclusions in the study include minors under the age of 18 with Lisfranc injuries, opinions, commentary or review, and case reports.

Results

Stavlas et al. conducted a systematic review of the treatment of Lisfranc injuries with reduction and internal fixation techniques. A total of 16.3% of those patients underwent closed reduction and internal fixation with screws, 66.5% with the ORIF technique with screws, and 17.1% with ORIF and K-wires to stabilize the 4th and 5th metatarsals. The study sought to address the overall rate of complication with reduction and internal fixation techniques and concluded that ORIF with screws was a reliable method. Infections and other complications related to the screws made up 16.1% of total patients from the first two groups. Further research showed 49.6% of the total cases developed secondary arthritis, and 2.6% of cases reported with compartment syndrome.[7]

In a randomized study by Ly et al. in 2006, 21 patients were treated with the PA technique, while 20 with the ORIF technique. The difference in anatomical reduction rate was insignificant between the two groups, with approximately 95% for the PA group and 90% for the ORIF group. The AOFAS score was significantly higher in the PA group, at 86.9% compared to the ORIF group at 64.2% ($p<0.005$). Another comparison, the rate in which the patient returned to full physical activity for PA was at 71.4%, while the rate for ORIF was only at 30%. The rate of complication for the PA technique was at 35%, while the rate of ORIF doubled at 70%. They concluded that PA of the medial two or three rays was a better treatment choice compared to ORIF.[9,10]

A prospective randomized study by Henning et al. in 2009 consisted of 32 patients, 18 of those patients received surgical treatment with PA, and 14 with ORIF. The rate of additional surgeries was significantly lower in the PA group at 16.7% than ORIF at 78.6% during three months, six months, twelve months, and twenty-four months follow-ups. They concluded that PA resulted in a significant decrease in the need for follow up surgeries if the hardware was removed consistently. An AOFAS score obtained to determine clinical outcomes further demonstrates that the PA technique was superior to the ORIF technique. A patient satisfaction survey consisting of quality of life and range of motion was collected during these follow-ups showed that patients who underwent PA technique are generally more satisfied than patients who underwent ORIF.[8]

A 2017 retrospective comparative cohort study by Cochran et al. looked at young military athletes (average age of 28) from 2010-2015 who were treated with PA or ORIF.[1] There were a total of thirty-two patients in the study, including 14 patients treated by PA, and 18 patients treated by ORIF. The

study reviewed the implant removal rates, fitness test scores, return to duty rates, and the Foot and Ankle Ability Measure (FAAM) scores.[1] Patients who underwent the PA technique had an 86% return to duty rate after an average of 138 days. On the other hand, 89% of the ORIF group returned to duty at an average of 209 days, roughly over two months longer than the PA group. FAAM scores were insignificant between the two groups, at 84.7 for ORIF and 83.3 for PA. A one-mile jog fitness test was conducted for the ORIF group 369 days post-op showed a 39 second lag compared to before treatment. Meanwhile, the test conducted for the PA group 320 days post-op showed only a 9 second lag. Furthermore, 83% of ORIF patients required implant removal, while only 14% in PA patients.[1]

A second retrospective comparative study conducted by Hawkinson et al. in 2017, also followed military patients that suffered from the same injuries from 2009- 2014 using the Department of Defense Trauma Registry and Military Health System Mart to identify these patients.[11] Out of the total of 111 patients in the study, 91 were treated with ORIF, and 20 were treated with PA. Of the 91 patients that underwent ORIF, 7 required a salvage arthrodesis (SA). Out of the 20 PA patients, 1 required a SA. The data demonstrated that there is a significantly lower rate of return to service in patients who underwent SA as a secondary procedure or failed ORIF. The 80% return to duty rate for PA was not significantly higher than the 65% return to duty rate of the ORIF group ($P= 0.4$). There was no significant difference between the rate of return to duty of patients who were treated with ORIF or PA. They suggest that younger and more active patients would benefit more from the PA than an ORIF.[11]

A meta-analysis by Han et al. in 2018 consisting of 5 retrospective studies and 2 randomized studies found that PA is superior over ORIF in the treatment of Lisfranc injuries. They based this on five patient outcome scores that included the AOFAS score, return to duty rate, complications, and VAS scores.[9] Hardware removal was statistically significantly decreased with arthrodesis compared to ORIF ($P<0.001$). Per Han et al., there was no significant difference in anatomic reduction rate revisions surgery rate, or total complications, but that PA did result in statistically significant increase in AOFAS score and return to duty rate suggesting that PA may be the superior treatment option for Lisfranc injuries.[9]

Discussion

In previous years, arthrodesis was seen as a way to correct post-ORIF complications or unsalvageable joints.[11] Recently studies have now begun to reveal PA as an equivalent surgical option and show better therapeutic effects compared to ORIF.[12]

Stavlas et al., published one of the first comprehensive reviews on the treatment of Lisfranc injuries in 2012. Base on available research at the time, they were unable to determine if ORIF or PA was the better surgical choice.[7] Cochran et al. further revealed that although their results indicated that there were no differences in the FAAM scores after three years' time, after 1 year PA decreased the amount of time to return to full capacity, had slightly better fitness scores, and had lower implant removal rates in comparison to patients treated with ORIF.[1]

Certain aspects of Lisfranc injuries are widely accepted and include the following; proper anatomical reduction improves surgical outcomes, stabilization of the lateral column with K-wires, and the two most common complications post-surgery are arthritic changes and screw failure.[7]

The meta-analysis conducted by Han et al. found that screw removal post-surgery for ORIF is one of the most common complications of Lisfranc injuries.[9] This meta-analysis was deficient in that it only collected data from 2002-2017 that only was able to include 93 patients treated with PA and 184 patients treated with ORIF. This small sample size introduced bias and was limited in that the review only had the two randomized control trials done by Ly and Henning.[7,8,10] The meta-analysis looked at the data with multiple grading scores (AOFAS and VAS) and took into account return to work data. Further prospective randomized control trials are necessary to get a better picture of what treatment, in what situations is best for the patient.[9]

Henning et al. results favored the PA technique over the ORIF technique. However, several limitations exist that require improvement for future studies. The small sample size makes it hard to draw a robust comparison between the two methods. Furthermore, satisfaction surveys did not account for the surgeon's skills that could lead to probable outcomes or probability of revision surgeries. Lastly, studies in the future should be conducted for longer than two years to track any long-term degeneration.[8]

Ly et al. confirmed previous studies and continued to support that the PA technique is superior over the ORIF technique. Despite these results, several limitations exist. Hardware removal post-ORIF could have contributed to its higher rate of complication over the PA technique. Lastly, the attending surgeon also conducted the post-operative questionnaire to assess clinical outcomes, introducing the possibility of bias.[10]

The study by Hawkinson et al. has several limitations. One of which is the uneven distribution

between the PA and the ORIF groups. Out of the total of 111 patients, 91 patients underwent ORIF, while only 20 underwent PA. Overall, the nature of the study assessed only for short term outcomes and lacks long term outcome assessment.[11]

Looking forward, Ponkilainen et al. have released a study protocol that will aim to address a majority of the questions and issues seen in the past literature. They will discuss two significant problems: to compare cast immobilization vs. ORIF of non-dislocated Lisfranc injuries, as well as to compare ORIF and PA treatment of dislocated Lisfranc injuries.[3] They have designed a prospective RCT that hypothesizes that cast immobilization will be equivalent to ORIF and that ORIF yields a similar functional outcome compared to PA, but that PA results in fewer post-injury surgeries.[3] They have identified the need for a minimum of 60 patients in each category and will compare the data following the conclusion of the study after a two year follow up period has concluded in 2021. The authors note that a limitation of the study includes limited patient blinding. This study will allow a more explicit definition as to which surgical procedure is best at treating Lisfranc injuries. Although limitation exists due to the small sample size of thirty-two patients, the study aims to provide more clear and conclusive data that will control for many of the biases seen in past literature.[1,3]

Conclusion

A careful assessment of each technique is necessary due to the natural complexity of Lisfranc injuries. Overall, the data suggest that the PA technique may be better than the ORIF technique for Lisfranc injuries. Results have shown a faster returning to duty rate, a better fitness score, a lower implant removal rate, a lower rate of complication, and a higher American Orthopedic Foot and Ankle Society score for the PA technique. However, further studies with larger sample sizes are crucial for the comparison between ORIF versus PA techniques in the treatment of Lisfranc injuries. Two randomized controlled trials published in the literature gave conflicting results, and there is a need for more research with a higher volume of patients to understand the best way to treat Lisfranc injuries.[8,10] Until further research, both methods are still considered to be excellent methods for the treatment of Lisfranc injuries.

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A Comparison Between Magnetic Resonance Imaging and Ultrasound for Identification of Plantar Plate Rupture

Tien Nguyen[+], B.S., B.A, Brittany Nguyen[+], B.S., and Alexis Conley[+], B.S.

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objective: Magnetic resonance imaging and ultrasound are two imaging modalities that are often utilized when identifying specific musculoskeletal pathology, including the diagnosis of plantar plate tears. The goal of this paper is to determine whether magnetic resonance imaging or ultrasound, is more accurate in diagnosing a plantar plate tear.

Methods: The EBSCO database was used to access articles. The keywords searched were, "MRI vs US of Plantar Plate Tear." Only peer reviewed papers written in English that compared sensitivity, specificity, negative predictive values, and positive predictive values were included. Four papers fit the inclusion criteria and were included in our study.

Results: Three of the included studies suggested that ultrasound had a higher sensitivity compared to magnetic resonance imaging and two of the studies suggested magnetic resonance imaging had a higher specificity compared to ultrasound. Overall, two of the four studies concluded that magnetic resonance imaging was more accurate than US while the other two studies stated the opposite.

Conclusions: This paper failed to distinguish which imaging modality is superior. However, as both show comparable results for detecting plantar plate tears, both imaging modalities should be used as adjuncts to each other to provide the most accurate diagnosis and treatment for patients.

Introduction

Imaging is a critical tool in the diagnostic process as physicians try to discern injuries with similar presentations from one another. Magnetic resonance imaging (MRI) and ultrasound (US) are commonly used to determine whether a ligament or tendon has been torn.[3] These two imaging modalities have been compared against one another based on their sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for certain anatomic components. For example, Khan et al. 2003 conducted a study that compared these aforementioned results of US versus MRI in the diagnosis of Achilles tendon disorders. They found that US had a higher PPV, while MRI had a higher sensitivity, specificity, and NPV.[1] In 2010, Rutten et al. compared imaging modalities for assessing rotator cuff tears and found that US had a higher sensitivity and NPV, while MRI had a higher specificity of 0.98 and PPV.[2] Neither study was able to conclude that one imaging modality was superior to the other in the diagnosis of the respected injury.

Injury to the plantar plate is another example of an anatomical region that often requires the use of imaging to confirm the diagnosis. The plantar plate is a fibrocartilaginous support that spans the plantar aspect of the metatarsal heads and associated proximal phalanx base. Distally, it attaches to the proximal phalanx, laterally, it attaches to the deep transverse intermetatarsal ligaments, and proximally to the metatarsophalangeal joint and periosteum of the lesser metatarsal. It functions to keep the metatarsophalangeal joint in alignment and stabilize the forefoot. Damage to the plantar plate can cause dorsal dislocation of the proximal phalanx on the metatarsal head and limit movement secondary to pain.[3] The goal of this paper is to compare the sensitivity, specificity, and predictive value of MRI and ultrasound to determine which imaging modality more accurately diagnoses a plantar plate tear.

Methods

The EBSCO database was used to access articles using the key search words, "MRI vs US of Plantar Plate Tear." Inclusion criteria was limited to research that compared the sensitivity, specificity, positive predictive value (PPV), positive likelihood ratio (PLR), negative predictive value (NPV), negative likelihood ratio (NLR) of MRI and US for diagnosis of plantar plate tears. Only peer-reviewed papers and those written in English were included. Our exclusion criteria omitted papers written prior to 2005. Of the thirty papers on plantar plate tears that were reviewed, only four papers fit the inclusion criteria stated above and these were included in our study.

Results

In a study conducted by Klein et al. 2012, both US and MRI were used to examine 51 feet from

46 patients. Of the 51 feet examined, 46 plantar plates tears were identified during operation. They found that US had a sensitivity of 0.915, a specificity of 0.250, a PPV of 0.915, and an NPV of 0.250. For MRI, they found that the sensitivity was 0.739, the specificity was 1.000, the PPV was 1.000, and the NPV was 0.294.[3] Furthermore, they separated the tears into different grades, and primarily focused on the ability of MRI to identify Grade 0, I, II, III, and IV tears. Grades were based on a plantar plate dysfunction grading system developed by Nery et al. in 2012.[4] Description of each grade along with the number of patients found with each grade can be found in Table 1. No patients had a grade I or IV tear. Of the three patients with grade 0 MRI found one with a tear while US did not detect any tears. Of the grade II tears examined, MRI correctly identified 19 out of 26 tears, while US correctly identified 24 out of 26 tears. For Grade III tears, MRI identified 14/17 while US identified 16/17.

In a separate study, Gregg et al. 2006 used US and MRI to diagnose lesser plantar plate tears from six soft-embalmed cadaveric feet. The cadaveric feet included were imaged and then dissected. Of the 24 lesser plantar plates in total, they found tears in 23. Results showed that US had a sensitivity of 1.00, a specificity of 0.00, a PPV of 0.96, and an NPV of 0.00.[5] For MRI, the sensitivity was 0.96, the specificity was 0.00, the PPV was 0.96, and the NPV was 0.00. Data showed that US was 96% accurate, while MRI was only 92% accurate at diagnosing plantar plate tears.

A 2017 study by Donegan et al. examined 12 patients intraoperatively and discovered that 10 patients had torn plantar plates. US had a sensitivity of 1.00, a specificity of 1.00, a PPV of 1.00, and an NPV of 1.00.[6] For MRI, the sensitivity was 0.60, the specificity was 1.00, the PPV was 1.00, and the NPV was 0.33. They found that US was 100% accurate, while MRI was only 66% accurate.

Duan et al. 2017 performed a meta-analysis on seven studies that included 246 plantar plate tears. US had a sensitivity of 0.93 and a specificity of 0.33, while MRI had a sensitivity of 0.95 and a specificity of 0.54.[7] US had a PLR of 1.2 and NLR of 0.35. For MRI, the PLR was 2.08 and the NLR was 0.08. They performed a summary receiver operator characteristic test to determine which of the two imaging modalities was more accurate. Based on the test, MRI was more accurate than US.

Grades	Description	Number of Patients
0	On intraoperative exam, plantar plate is discolored or attenuated	3
1	Transverse tear less than 50% of the attachment to the base of the proximal phalanx	0
2	Transverse tear greater than 50% of the attachment to the base of the proximal phalanx	27
3	Extensive longitudinal or transverse tear	13
4	Extensive tear with button hole or dislocation	0

***Table 1**: Description of certain grades of plantar plate tears including number of patients with each grade.*

Discussion

MRI and US are both considered accurate methods for capturing and diagnosing soft-tissue pathologies. Multiple studies have sought to determine which was the superior imaging modality to provide the best patient care. Klein et al. acknowledged that US is faster, more cost effective, and more comfortable for the patient in comparison to MRI. MRI has a significantly lower sensitivity and higher specificity in comparison to US. However, MRI was more successful in the identification of plantar plate tears and localization of grade II and grade III tears in comparison to US. Due to this reason, they concluded that US should not replace MRI in all plantar plate pathology cases. One of the weaknesses of this study that the authors mentioned was that the number of participants was low. The author mentioned that both MRI and US were appropriate for soft tissue pathology in this study and the results from this study are comparable to other studies that compared the two imaging modalities.

The study conducted by Gregg et al. 2006 concluded that US is comparable to MRI in diagnosing plantar plate tears. US was able to identify one tear that MRI did not detect, suggesting that MRI was less sensitive in comparison to US. The accuracy for both imaging modality was high, however, both had low specificity. Some of the limitations of the study was the small sample size and the advanced age of the embalmed cadavers which ranged from 74-92 years old. The authors noted they had trouble penetrating the tough, callused skin and thickened fat pad with the ultrasound. The accuracy of the ultrasound results may have been affected.

Donegan et al. 2017 found results that juxtapose those of the previously mentioned studies. Their research found that there was no statistically significant difference between US and MRI in the evaluation of damage to the plantar plate. The authors

mentioned that the results they found were comparable to other studies that compared the two imaging modalities. They concluded that ultrasound was at least equivalent to MRI and that it could even be superior to MRI. The small sample size and predominantly female population studied were considered to be the limitations of this study. One of the strengths of this study was that the imaging for each patient was taken by the same radiologist. Similar to previous studies, they mentioned that the use of intraoperative inspection helped standardized the findings.

The meta-analysis performed by Duan et al. 2017 also concluded that MRI was more accurate than ultrasound in plantar plate tear identification and diagnosis. The study determined this due to the MRI having higher specificity and positive likelihood, lower negative likelihood, and similar sensitivity. The study acknowledged that their results may have been influenced by statistical heterogeneity due to possible inconsistencies in MRI radiologists and magnetic field values in the MRI. The magnetic field values were not standardized and ranged from 0.3 to 1.5 Telos. They also stated that the duration of reference and index scan were poorly documented, and that there could be disease progression bias which leads to misclassification.

Overall, the results for the studies showed that US is comparable to MRI for detecting plantar plate tears. The results were also comparable to other studies that compared these two imaging modalities. Three of the four studies had a common limitation in which the sample size was small. Having a small sample size could lead to skewed results. As such, only Duan et al. had a large sample size and they concluded that MRI was more accurate than US. However, there needs to be more research comparing these two imaging modalities on detecting plantar plate tears before one can finally conclude if one of the imaging modality is more superior to the other.

Conclusion

US and MRI are two imaging modalities often used to determine whether a ligament or tendon has been torn. All four papers showed comparable results between US and MRI for detecting plantar plate tear. However, two studies concluded that MRI was more accurate and the other two studies concluded that US was more accurate. This paper failed to distinguish which imaging modality is superior. Since both are comparable for detecting plantar plate tears, both imaging modalities should be used as adjuncts to each other. By using both US and MRI, clinicians can gain a more complete understanding of a patient's plantar plate tear and can use this information to determine the most effective treatment plan.

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Morganella morganii Sepsis in the Presence of a Clinically Benign Diabetic Heel Ulceration: A Case Report

Shivam Patel+, B.S., Linda Chow+, B.S., and Wendy Carabajal*, B.S.

+Western University of Health Sciences, College of Podiatric Medicine
*Western University of Health Sciences, College of Health Sciences

ABSTRACT

Objective: The objective of this case report is to present a lower extremity diabetic ulceration as a previously unreported primary inoculation site of *Morganella morganii* infection.

Methods: Hospital records of the patient were reviewed in detail to elucidate the pathogenesis and progression of the infection. All identifying information was excluded in accordance with HIPAA and PHI guidelines.

Case Report: A 64-year old male presented to the emergency department in septic shock and was subsequently admitted to the inpatient ward. *M. morganii* was isolated as the pathogen on day six after admission. Despite receiving empiric antibiotics throughout the hospital course, effective coverage was not achieved until hospital day four. The infectious workup revealed a clinically and radiographically benign posterior heel wound as the portal of entry for the pathogen.

Conclusion: *M. morganii* is a rare but potentially devastating nosocomial pathogen that can occur in the lower extremity in diabetic patients. While the prevalence is low, the potential complications and difficult nature of treatment make it an important pathogen to consider.

Introduction

According to a 2017 Centers for Disease Control and Prevention (CDC) press release, 30.3 million adults in the United States are living with diabetes mellitus (DM), with another estimated 84.1 million adults are considered prediabetic.[1] Development of diabetic foot ulcerations is a feared complication of longstanding and untreated DM; the prevalence is reported to be 4-10% with 50% recurrence within three years.[2,3] Infections commonly follow ulcerations and can stay localized or cause systemic illness. Morbidity and mortality are significant consequences of lower extremity infections and amputation is often required in survivors. A 2004 study of 788 patients conducted by Aulivola et al. found a 30-day mortality rate of 14.3% in lower extremity guillotine amputation for sepsis control.[4]

The most common portals of entry for *M. morganii* are the urinary and hepatobiliary tracts.[5] Skin and soft tissue entry have been reported to occur post-operatively, but not primarily in the diabetic foot. The lower extremity is not well characterized as a portal of entry for the pathogen. Only one major study published to date has described *M. morganii* infection through the lower extremity. However, this case, described by Lambourne McCulloch et al. in 2018, was a report of sepsis occurring secondary to myiasis in a non-diabetic patient.[6]

The microbe is often unconsidered as a potential pathogen in the podiatric setting, delaying adequate treatment in a potentially life-threatening infection. The objective of this case report is to present a lower extremity diabetic ulceration as a potential inoculation site of *Morganella morganii* infection.

Background

The association between diabetes and an increased risk of infection is well documented. A hyperglycemic cellular environment leads to dysregulation of the cellular immune response. Hyperglycemia disrupts the complement system activation pathway, causes a decrease in the secretion of multiple inflammatory cytokines, decreases the mobilization and activation of leukocytes, and causes glycation of immunoglobulins.[7]

Due to this state of immunocompromise, diabetics have increased susceptibility to abnormal pathogens in certain regions of the body. Examples include rhinocerebral mucormycosis, gangrenous cholecystitis, and lower extremity infections.[7] Common pathogens include *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Proteus sp., Klebsiella sp.,* and *Citrobacter sp.* [7]

First discovered in 1906, *M. morganii* is a member of the *Enterobacteriaceae* family. It is a nosocomial gram-negative, facultative anaerobic rod capable of producing multiple virulence factors.[8] Antibiotic resistance is a major consideration with *Morganella*; strains are commonly encountered as multi-drug resistant or extensively-drug resistant. The pathogen is recognized as a member of the SPACE (Serratia sp., Pseudomonas sp., Acinetobacter sp., Citrobacter sp., Enterobacter sp.) organism group, and as such, it has the ability to express the AmpC β-

lactamase gene as inducible or constitutive.[8] The AmpC gene encodes for hydrolytic β-lactam enzymes that are able to lyse drugs in the penicillin, cephalosporin, and monobactam families. Additionally, it is important to note that the β-lactamases encoded by AmpC are not inhibited by β-lactamase inhibitors. The pathogen is also able to produce extended-spectrum β-lactamase, further increasing its resistant capabilities.[9] Other significant reports of resistance have been reported globally; a 2015 study by Wang et al. detailed carbapenem-resistant strains of the pathogen.[10] The potent combination of multiple virulence factors with multiple resistance mechanisms makes the organism difficult to manage when encountered in the clinical setting.

Case Report

A 64-year old male with extensive history of uncontrolled type 2 diabetes mellitus and peripheral vascular disease presented to a Los Angeles County emergency department (ED) in septic shock with bacteremia of unknown origin. He had a chronic, non-healing ulceration exposing the Achilles tendon of five months duration on his right posterior heel that appeared to be uninfected on clinical and radiographic evaluation.

The patient did not recall any inciting event but endorsed a two-day history of progressive fevers, chills, nausea, dyspnea, and shortness of breath. Peri-wound erythema, edema and drainage were not appreciated upon physical exam. Laboratory values indicated an elevated white blood cell count with neutrophilic predominance, hyperkalemia, lactate dehydrogenase, and elevated C-reactive protein.

The patient was given a course of vancomycin and piperacillin-tazobactam in the ED and switched to ceftriaxone and metronidazole upon admission. Blood cultures were drawn in the ED, but after two days the pathogen had not been identified by PCR assay. Gram stain revealed gram-negative rods without speciation, and due to the lack of identification, no susceptibility data was available.

The patient remained hemodynamically unstable despite empiric antibiotic therapy and was escalated to ertapenem. The patient began to stabilize with ertapenem, but identification of the microbe was not completed for another two days, totaling four days since admission. The susceptibility report revealed that the pathogen was susceptible to ertapenem, cefepime, and trimethoprim-sulfamethoxazole at this time. The patient was eventually discharged as stable with a peripherally inserted central catheter for an extended course of IV ertapenem. The patient was lost to follow-up after discharge.

Throughout the hospital course, infectious workup was conducted to find a source of the bacteremia. Urinary tract infections are known to seed systemic vasculature in patients of advanced age. However, urine cultures did not reveal an infection seeding the bloodstream in this patient. Transthoracic echocardiogram and abdominopelvic CT scans were also non-contributory. Infectious workup ultimately revealed the diabetic wound as the source of the infection but required extensive evaluation to rule out other more common causes.

Discussion

M. morganii sepsis is a rare, but extremely serious condition, as evidenced by this patient's hospital course. The complexity of management and difficult nature of identification contributes to the difficulty in treating this pathogen. There was a significant delay before effective antibiotics were administered in this case and different resistance pattern could have resulted in an unfavorable outcome.

With the increasing prevalence of DM reported by the CDC in 2017, it is reasonable to predict that the prevalence of diabetes-related ulcers and infections will increase accordingly. As such, it is important to consider the variable range of patient presentations and pathogens possible.

While PCR assays are excellent for identifying the most common pathogens, the technology has limitations. The assay utilized in this case tests for 24 bacteria. *M. morganii* is not on the panel, and as such, identification requires manual processing. This causes a significant delay in obtaining objective microbiological data and can make treatment much more difficult. Incorrect administration of antibiotics can cause induction of the AmpC gene in certain strains, which would confer additional resistance and complicate the treatment course. Avoiding the use of ceftriaxone would be prudent in this case due to possible rapid development of resistance. Therefore, early and correct identification of this uncommon pathogen in diabetes-related ulcers is beneficial to treatment outcome.[11]

Conclusion

This case demonstrated the difficult nature of *M. morganii* sepsis with an abnormal portal of entry. It is often overlooked in the podiatric setting, but consideration of the pathogen could prove to be beneficial in improving patient outcomes. Further study into the prevalence of the microbe in the diabetic foot would be beneficial.

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The Late Effects of Poliomyelitis: A Review

Ifeoluwa Adesina[+], B.S., M.S. and Brianna Novak[+], B.S.

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objective: The goal of this article is to discuss the late effects of poliomyelitis on balance, muscle strength, and gait performance in the lower extremities as well as the increased risk of falling among this population and ways to rectify it.

Methods: The authors used Google Scholar, PubMed, and Science Direct to find and review of articles dating from 2005-2019, which address disease epidemiology, prevalence, and its influence on lower extremity strength among polio-virus survivors.

Results: The incidence of polio virus infection has significantly dropped since 1894; however, worldwide, there remains 15-20 million survivors who are still dealing with the long-term effects of infection commonly referred to as Post-Polio syndrome. In reviewing three studies, it is widely proven that the reoccurrence of symptoms after over 20 years of exposure to polio virus leads to reduced muscle strength, gait performance and postural imbalance.

Conclusion: The impact on the motor neurons and its subsequent effects on mobility are of huge concern as it impedes the individual's simple daily activities and puts the individual at increased risk of falling and injury. Some solutions have been implemented to help these individuals overcome the physical obstacles they face from having this disease such as orthotics and grab bars; however, adherence and uptake of these treatment options has room for improvement and further research.

Introduction

Poliomyelitis results from infection by the polio virus, whose symptoms were first documented in the United States in 1894.[1] Entrance of the virus is via the fecal-oral route then replication occurs in the pharynx and GI system. After weeks of incubation, the disease can invade the bloodstream through lymphoid organs and potentially infect the central nervous system (CNS). This infection of the CNS and subsequent destruction of motor neurons is responsible for the pathogenesis of poliomyelitis. Poliomyelitis can result in paralytic or non-paralytic manifestations with paralytic polio associated with a longer incubation time.[2]

The prevalence of the polio epidemic was most widespread during the late 1800s and mid 1900s, but then underwent a rapid decline after 1954 due to the introduction of the Polio vaccine.[1]

Figure 1: *Effects of the Poliovirus. Adapted from the Centers of Disease Control and Prevention's Public Health Image Library.*[4]

Immunization allowed for the eventual eradication of the disease in most of the globe in the 1990s –Europe, West Pacific, Southeast Asia, and America. However, the polio-endemic continues to plague Pakistan, Afghanistan, and Nigeria.[2,3] Additionally, there are significant number of survivors living with the long-term effects of poliomyelitis, which is commonly referred to as Post-Polio Syndrome (PPS).

PPS develops 15-40 years after an individual acquires acute paralytic poliomyelitis and is characterized by new onset muscle weakness, fatigue, pain or paralysis as well as a collection of other symptoms experienced by polio survivors.[5] Individuals are most susceptible to developing PPS if significant time has passed since acute infection, initial disease was severe in intensity, acquisition of polio was later in life, the patient is female or had a history of respiratory complaints during initial disease process.[5,6] Other reported symptoms include difficulty breathing, sleep disorder, loss of stamina, cold intolerance, cardiovascular disorders, musculoskeletal deformities, restless leg syndrome, and psychosocial problems.[6] The goal of this article is to discuss the late effects of poliomyelitis on balance, muscle strength, and gait performance in the lower extremities as well as the increased risk of falling among this population and ways to rectify it.

Background

Poliomyelitis is typically spread via fecal-oral route, but there is also evidence that direct person-to-person transmission may also

contribute.[2] The main infection related to this virus is enteritis with prodromal illness of fever, headache, arthralgia, vomiting, and diarrhea lasting for 3-4 days.[7] Half of the people affected do not develop paralytic symptom, but in the other half, a biphasic course evolves.[7] As the initial enteritis subsides, the paralysis begins. The infection progresses to the anterior horn motor neuron in the gray matter of the spinal cord causing cell death, which leads to disruption of the motor unit causing muscle weakness and other symptoms to manifest.[7,8] Paralysis tends to come on in a patchy, multifocal distribution.[8] Muscle weakness comes first in a couple of days and typically reaches a maximum after 1 week.[8] The virus is characterized primarily by fatigue, muscle weakness, and the reduction in lower limb muscle strength. These are likely the main reasons for impaired balance, slow gait and dysfunctional kinematics seen in poliovirus survivors. Due to these impairments, the risk of these survivors falling is about four times more than the age matched healthy person.[10]

Methods

Google Scholar, PubMed, and Science Direct search engines were used to find a total of 12 published articles relevant to the late effects of polio on lower extremity muscle strength, gait, and balance. Several articles and studies were identified using keywords such as "postpolio syndrome," "aging," "quality of life," "late effects of polio," "paralytic poliomyelitis," and "polio survivor," "risk of falling," "muscle weakness," "gait," and "orthotics." Articles unrelated to the objective of this paper as well as those that required fees for access were excluded. Of the studies reviewed, three were selected to be included in this review as they addressed our objective.

Results

In a study done by Brogårdh et al., 81 ambulatory persons with verified late effects of polio determined how muscle strength, balance, and gait are associated with falls and fear of falling in these individuals. Of the participants studied, 59% reported at least 1 falling episode in the past year and fear of falling (FOF) was expressed by 79% of people.[9] Two major determinants of falls identified in the study were gait performance and decreased knee muscle strength. Researchers found that participants with an increase in knee extensor and flexor strength of 10Nm diminished the odds ratio between 0.70 and 0.83 (P=0.1). Additionally, a reduced odds ratio to 0.41 (P=0.001) was found with an increased 100m 6-minute walk test.[9]

Demographics and clinical characteristics of the 81 participants with late effects of polio, divided into fallers and nonfallers

	Fallers (n = 48)	Nonfallers (n = 33)	*P* Value
Age, mean years ± SD (range)	67.5 ± 6.0 (56-80)	65.1 ± 7.5 (35-74)	.13
Gender, men/women, n	22/26	19/14	.30
Body mass index, mean ± SD (range)	27.5 ± 4.1 (18-38)	26.0 ± 3.3 (21-35)	.08
Strength measurements (60°/s)			
More affected limb			
Knee extension, Nm, mean ± SD (range)	54.2 ± 37.6 (0-168.5)	84.5 ± 44.4 (0-161.8)	.25
Knee flexion, Nm, mean ± SD (range)	28.4 ± 18.0 (0-61.7)	45.9 ± 26.9 (0-103.2)	.002
Less affected limb			
Knee extension, mean ± SD (range)	98.2 ± 46.1 (5.1-196.5)	109.8 ± 42.8 (23.2-210.5)	.15
Knee flexion, mean ± SD (range)	53.5 ± 25.2 (0.8-131.0)	61.6 ± 24.0 (7.1-112.2)	.002
Dynamic balance			
Timed Up & Go, s, mean ± SD (range)	11.3 ± 4.3 (6.9-32.8)	9.7 ± 2.2 (7.2-17.9)	.03
Gait performance test			
6-Minute Walk test, m, mean ± SD (range)	396 ± 93 (140-590)	477 ± 103 (250-720)	.001
Fear of falling			
FES-I, points, mean ± SD (range)	30.9 ± 8.8 (18-54)	23.4 ± 8.6 (16-46)	<.001

Fallers = those that reported at least one fall during the last year; nonfallers = those that did not report any falls during the last year. Continuous variables were analyzed with the independent sample *t*-test and categorical variables with the Mann-Whitney *U* test.

Table 1: *Demographics and clinical characteristics of fallers and non-fallers. Adapted from Brogårdh et al. "Determinants of Falls and Fear of Falling in Ambulatory Persons with Late Effects of Polio."*[9]

The association between FOF, knee muscle strength, dynamic balance, and gait performance for the 81 participants with late effects of polio

	FOF Unadjusted				FOF Adjusted for Falls, Gender, Age, BMI			
Regression Model	B	95% CI	*P* Value	R^2	B	95% CI	*P* Value	R^2
Strength more affected limb								
Knee extension 60°/s, 10 Nm	−1.12	−1.55 to −0.70	.001	0.25	−1.07	−1.53 to −0.60	.001	0.32
Knee flexion 60°/s, 10 Nm	−1.68	−2.49 to −0.87	.001	0.17	−1.40	−2.36 to −0.45	.005	0.22
Strength less affected limb								
Knee extension 60°/s, 10 Nm	−1.08	−1.48 to −0.67	.001	0.25	−1.12	−1.55 to −0.69	.001	0.36
Knee flexion 60°/s, 10 Nm	−1.90	−2.64 to −1.17	.001	0.24	−2.34	−3.23 to −1.44	.001	0.36
Dynamic balance								
Timed Up & Go test, s	1.44	0.96 to 1.92	.001	0.30	1.27	0.77 to 1.76	.001	0.36
Gait performance								
6-Minute Walk test, 100 m	−5.84	−7.39 to −4.29	.001	0.41	−5.21	−6.98 to −3.45	.001	0.41

Results were obtained by univariable and multivariable linear regression analyses. Knee muscle strength is calculated in intervals of 10 Nm and gait performance in intervals of 100 m.

FOF = fear of falling; BMI = body mass index; 95% CI = 95% confidence interval; B = unstandardized beta coefficients.

Table 2: *Determinants associated with FOF. Adapted from Brogårdh et al., "Determinants of Falls and Fear of Falling in Ambulatory Persons with Late Effects of Polio."*[9]

Another study (Brogårdh et al., 2014) of 325 persons (175 women and 150 men) investigated fall frequency and the conditions relating to fall, fear of falling, and walking limitations in people with the late effects of polio. Data regarding the demographics were obtained through a questionnaire and of the 325 participants, 62% reported at least one fall during the past year and this has led to an increase in the fear of falling, which ultimately impairs the performance of daily activities.[10] In another study, Genêt et al evaluated the long-term effect of PPS on the knee, as this joint is the most problematic and also makes a huge impact on gait. Researchers found that knee recurvatum above 10° will cause pain and creates functional shortening of the hamstring. This pulls the knee backwards, causing a limp. There are different types of gait patterns seen in these patients; some of the classic ones include: shoulder swing limp pattern, locked knee, walking with the hand on the thigh to lock the knee; all of this to try to stabilize their gait and make life easier every day.[11]

Lastly, a qualitative study of 14 ambulatory persons with late effects of polio showed an increased probability and unpredictability of falling. These individuals were interviewed, and the overarching result was that having polio resulted in them having a decreased control over movements, making everyday life a challenge. Falling could occur anywhere and anytime and had dramatic psychological and physical consequences on the participants.[12]

Discussion

The overarching theme of these studies is that individuals suffering from the late effects of polio have increased muscle weakness, which contributes to decreased stability and gait performance. These impediments to mobility significantly augment an individual's chance of falling and fear of falling compared to a healthy person. This fear results in people with PPS being scared to perform even basic activities of daily living since most falls tend to occur when they are walking around familiar environments. Therefore, many individuals will choose to just remain inactive and opt for a more sedentary lifestyle to avoid the physical and emotional consequences of falling. This is problematic because decreased activity further deteriorates their physical condition and leads to decreased bone density as well as increased risk of osteopenia and bone fractures.[10] In addition to physical consequences, there are also emotional and psychological reactions after the fall. Some experience embarrassment while other feel anger and frustration. These emotions had even more dramatic effects when the falls occurred in public as opposed to a private setting. These psychological effects even further hinder the individual from performing his or her activities of daily living.[12]

Treatment and Management

In order to reduce falls and increase mobility, consultation with occupational therapy has been proven to be beneficial for patients. Adaptive equipment such as grab bars and stair glides can help make his or her activities of daily living less energy consuming. Gait aids and orthotic devices can also be used to limit fatigue. Ankle-foot or knee-ankle-foot orthoses can augment mobility as they can help compensate for weakening muscles, altered gait, deformities, and pain caused resulting from PPS. Essentially, the current methodology used to treat and manage this condition is rehabilitation and symptoms

management aimed at limiting energy expenditures and muscle overuse to avoid fatigue.[13]

Conclusion

Although the prevalence of polio has been greatly reduced since the invention of the polio vaccine, there are still a significant number of survivors dealing with the late effects of poliomyelitis. The most notable clinical manifestations are seen in the lower extremities affecting an individual's muscle strength, balance and gait performance. These limitations are crucial determinants for the survivor's risk of falling and ability to perform daily activities. Orthotics and other assistive devices have shown to help individuals overcome these obstacles; however, there is a need for improved education and support by providers to encourage polio survivors to take advantage of the available treatment strategies.

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Tinea Pedis and Common Skin Mimics

Jacob Nelson[+], B.S. and Heather Kopecky[+], B.S.

[+]Western University of Health Sciences, College of Osteopathic Medicine of the Pacific-Northwest

ABSTRACT

Objective: The purpose of this article is to discuss errors related to tinea pedis diagnosis. An overview of clinically similar superficial dermatoses is provided to aid the reader in clinical differentiation and decision making.

Methods: A review of current literature regarding the identification and treatment of tinea pedis using keyword searches. We queried PubMed and Google Scholar. Search terms included: tinea pedis misdiagnosis, tinea pedis, contact dermatitis, allergic dermatitis, eczema, psoriasis, and erythrasma.

Results: Current research shows a high rate of errors related to diagnosis of superficial mycoses. A survey conducted at a dermatology meeting in 2016 showed that only 8 out of 13 clinical cases were correctly identified as fungal infection by more than 50% of the respondents using a clinical picture alone.

Conclusion: Tinea pedis can be difficult to differentiate from common dermatoses such as erythrasma, psoriasis, dyshidrotic eczema, and contact dermatitis. It is important to be familiar with subtle differences in clinical presentation and to perform the appropriate adjunct testing in order to avoid a delay of diagnosis.

Introduction

Dermatophytosis in the foot region, or tinea pedis, is an extremely common condition affecting an estimated 25% of the world's population and accounting for 51 million outpatient visits over a 10-year period (1995-2004) in the United States alone.[1] According to market research conducted by Future Market Insights, the global tinea pedis treatment market will be worth $1.7 billion by 2027.[2] Visually distinguishing between tinea pedis, commonly known as athlete's foot, and similar pedal skin conditions can be very difficult.[1] Through analysis of several surveys, this paper reinforces the suggestion that clinicians should utilize all available diagnostic tools such as Wood's lamp and KOH prep before treating based on appearance alone. The purpose of this article is to act as a guide for clinicians in diagnosing common cutaneous conditions affecting the skin of the foot through comparing and contrasting common features.

The physical exam findings for tinea pedis can be relatively non-specific, and easy to confuse with other conditions on the differential list.[1] The test typically used to confirm superficial fungal infection of the skin is known as a potassium hydroxide preparation (KOH prep).[3] The scaling perimeter of the suspected fungal lesion is scraped with a scalpel and prepared on a glass slide. 20% KOH or other specific fungal stain is added to the scrapings and then examined under a microscope to check for the presence of fungal hyphae.[3] This test is very cost effective and simple to perform.

Methods

An overview of differential diagnosis and treatment of tinea pedis and common mimics was compiled using PubMed and Google Scholar. Search terms included tinea pedis misdiagnosis, tinea pedis, contact dermatitis, allergic dermatitis, eczema, psoriasis, and erythrasma.

Background

Tinea Pedis

Most patients with tinea pedis may present with any of the three following clinical forms.[4] In addition to these findings, the patient will usually complain of itching and/or pain.

1. Interdigital tinea pedis which involves scaling, maceration possible fissuring in the spaces between the toes.
2. Moccasin type (hyperkeratotic) tinea pedis which presents with a scaling, erythematous eruption affecting the medial lateral and plantar aspects of the feet, also known as a "moccasin distribution."
3. Inflammatory or vesiculobullous tinea pedis which is seen as a vesicular or bullous eruption with erythema.[4]

Interdigital Erythrasma

Erythrasma is a common condition that can affect the interdigital spaces of the feet, and is caused by the gram-positive bacillus, *Corynebacterium minutissimum*.[5] Interdigital erythrasma and interdigital tinea pedis can be nearly indistinguishable due to similar scaling and maceration. Many clinicians and patients do not realize that a misdiagnosis has been made until 6 weeks of antifungal therapy has elapsed and minimal progress has been made, as erythrasma will respond only to antibiotic treatment.[6] In addition to performing a KOH prep to check for the presence of fungal hyphae, a classic exam finding that can easily

differentiate interdigital erythrasma is the "Coral Red" fluorescence under Wood's lamp examination.[6]

Dyshidrotic eczema

Dyshidrotic eczema will present as an intensely pruritic vesicular rash that usually affects the lateral aspects of the fingers but also can occur anywhere on the hands or feet. Patients typically do not exhibit scaling, however, in chronic cases scaling may be present.[7] The vesiculobullous form of tinea pedis and dyshidrotic eczema may share physical exam findings such as scaling and vesicles.[8] A KOH prep should be performed to determine whether corticosteroid or antifungal treatment should be started.[8]

Psoriasis

Psoriasis is classically described as silvery scaly plaques that are raised and erythematous. A specific subtype of psoriasis that affects the feet is known as plantar psoriasis. Patients may or may not present with psoriatic lesions at other sites. Psoriasis can appear similar to tinea pedis due to shared characteristics of scaling and erythema. The scaling in psoriasis is typically much more pronounced than in tinea pedis, but in some cases, it is still difficult to differentiate. There are also many overlaps in nail changes that occur in psoriasis and tinea pedis including nail pitting and discoloration.[9]

Contact/Allergic dermatitis:

Contact dermatitis of the foot can appear similar to moccasin type tinea pedis. Clinical history is important in differentiating the two looking for clues such as new shoes, new socks, new foot treatments, or exposure to other chemicals. Treatment involves identification and avoidance of the allergen and topical steroids to decrease inflammation. If one is still unsure about the etiology of the rash, a KOH prep is a useful tool to guide decision making and to avoid delay of proper treatment.[10]

Results

In 2016 Yadgar et al. published an article that included results form an interactive survey of board-certified dermatologists at the 2016 Orlando Dermatology Aesthetic and Clinical Conference. Attendees were shown a clinical picture and asked to determine whether or not the picture depicted a fungal process. In this survey, only 8 out of 13 clinical cases were correctly identified as fungus by the majority of respondents as can be seen in Table 1. Additionally, only 4 out of 13 clinical cases was correctly identified by greater than 75% of the respondents.[1] In a second study by Halvaee et al. in 2018, 80 clinical cases clinically suspicious for intertrigo were identified and then tested via KOH preps and fungal cultures to determine the causal organisms.[5] Of the 80 cases, 38 showed infections of the toe web spaces. While the most common diagnosis in these cases was dermatophytosis, at 55%, they also identified erythrasma and candidiasis as other causes at 42% and 3% respectively.[5] Lastly in a study by Pariser et al. in 1987, a group of 260 patients were seen for dermatologic complaints. The patients were first diagnosed in the primary care setting and then seen in the dermatology clinic where the diagnoses were verified or corrected. The study found that dermatophytosis was erroneously diagnosed in 79 cases.[11] The study also found that in 23 cases of true dermatophytosis, the diagnosis was missed, or underdiagnosed. A ratio of overdiagnosis to underdiagnosis was found to be equal to 3.4:1, making dermatophytosis much more likely to be erroneously ruled in, than erroneously ruled out.[11]

Case	Diagnosis	n (%) Yes	No
1	Secondary syphilis	16 (94.1)	1 (5.9)
2	Tinea corporis	7 (46.7)	8 (53.3)
3	Erosio interdigitalis blastomycetica	12 (70.6)	5 (29.4)
4	Tinea corporis	10 (52.6)	9 (47.4)
5	Tinea faciei	10 (58.8)	7 (41.2)
6	Pityriasis rosea	13 (76.5)	4 (23.5)
7	Tinea corporis	26 (86.7)	4 (13.3)
8	Majocchi granuloma	3 (13.0)	20 (87.0)
9	Tinea versicolor	18 (72.0)	7 (28.0)
10	Tinea pedis	22 (78.6)	6 (21.4)
11	Erythema annulare centrifugum	10 (33.3)	20 (66.7)
12	Woringer-Kolopp disease (pagetoid reticulosis)	12 (46.2)	14 (53.8)
13	Gram-negative toe web infection	2 (6.1)	31 (93.9)

Table 1: *Participant responses to clinical images. Adapted from JAAD, Table 1, Yadgar et al., 2016.*[1]

Discussion

All three studies contain the common theme that dermatophytosis diagnosis is prone to error when using a clinical picture alone. Pariser attributes these errors to a general lack of diligence in obtaining sufficient confirmatory tests such as KOH prep and/or fungal culture.[11] In recent literature, the sensitivity and specificity of the KOH prep were shown to be 95.7% and 69.6% respectively and it is simple, effective, and cheap to perform.[12] In addition, Halvaee et al. demonstrated in their study that even though a clinical case of intertrigo may appear fungal, bacterial erythrasma and candidiasis cannot be ruled out via visual inspection alone, again reinforcing the need for confirmatory testing.[5] It is explicitly concluded by Yadgar et al., that secondary syphilis, annular psoriasis, and pityriasis rosea can all

very effectively mimic tinea pedis. They infer that a great deal of importance should be placed on continued medical education regarding dermatophyte infections and their differentials including education on common bedside techniques such as performing KOH testing.[1]

Conclusion

Foot rashes are difficult to identify on physical exam alone, and they are commonly misdiagnosed in the primary care setting, as well as by dermatologists. Obtaining a thorough history, physical exam, and proper confirmatory tests are crucial to arriving at a correct diagnosis and to avoid unnecessary, ineffective, and costly treatments. The KOH prep is an inexpensive and easy to learn test which should be utilized by clinicians in the primary care and dermatology settings. Patients who are treated with the wrong medication such as corticosteroids when antifungals are warranted will not only accrue more costs associated with increased office visits but will also most likely see a worsening of their symptoms with undue discomfort. It is important to recognize that the differentials for tinea pedis are broad and to take time and care to rule out conditions before initiating treatment.

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A Review of How Social Factors Affect the Quality of Life in Lower Limb Amputees

Lovepreet Dhillon[+], B.S., Jaskirat Bhatia[+], B.A., and Jaspreet Thind[+], B.S.

[+]Western University of Health Sciences, College of Osteopathic Medicine of the Pacific-Northwest

ABSTRACT

Objective: Understanding the impact of mobility, employment, and body image on the quality of life of amputee patients compared to the general population.

Methods: A linear regression between the Mental Component Score and the Physical Component Score within the Short-Form 36 Health Survey was utilized to measure quality of life of lower limb amputation patients. Secondly, the analysis incorporated mobility, employment, and self-body image scores from studies that compared amputee patients and against the general population with regard to quality of life differences.

Results: A meta-analysis of five studies utilizing Short-Form 36 to measure quality of life in lower limb amputee patients revealed a strong positive correlation (r= .94) between the Mental Component Score and Physical Component Score. Compared to the general population**,** amputee patients had lower mobility, employment, and self-body image scores that negatively impacted their quality of life.

Conclusion: The strong positive correlation between the Mental Component Score and Physical Component Score components of the Short-Form 36, suggests that rehabilitation programs need to incorporate both physical and mental well-being. Additionally, addressing employment, body image, and mobility of lower limb amputee patients can improve amputee quality of life.

Introduction

In the United States, approximately 1.7 million individuals live with lower leg amputations.[1] These can be both unilateral or bilateral, and range from foot amputations, below knee amputations (BKA, trans-tibial), knee disarticulations, to above the knee amputations (AKA, trans-femoral). The causes of lower leg amputations are multi-faceted, with trauma, vascular disease, diabetic neuropathy via complications of infection, bone tumors, and congenital defects being the most common causes of amputation.[2] Individuals with lower leg amputations face issues with mobility, employment, and mental well-being. These factors are found to affect the Physical Component Score (PCS) and Mental Component Score (MCS) in the Short-Form 36 (SF-36). These concerns influence their quality of life (QoL). The World Health Organization defines QoL as encompassing 6 categories: Physical, Psychological, Level of Independence, Social relationships, environment, spirituality / religion / personal beliefs. Discerning these categories is important to better understand the social aspects facing lower leg amputees. Using the SF-36 is a cost-effective method to measure QoL. The score incorporates eight sections vitality, physical functioning, bodily pain, general health perceptions, physical role functioning, emotional role functioning, social role functioning, mental health. Moreover, understanding the differences between BKA and AKA are also important to better help patients with specific lower leg amputations. Overall, studying lower limb amputations can present healthcare professionals and rehabilitation specialists with meaningful opportunities to improve the QoL for lower leg amputees.[1]

Background

Mobility

Amputations affect mobility as individuals must adjust to their body after surgery.[1] The study, Wurdman in 2018 demonstrates that quality of life and satisfaction are strongly related to mobility for patients with lower limb prosthesis used the Prosthesis Evaluation Questionnaire- Well-Being subsection (PEQ-WB) to measure quality of life. PEQ-WB, consists of two questions that ask the patient about his or her satisfaction and quality of life since amputation.[3] For patients with lower limb prosthesis, a positive correlation has been found with quality of life and mobility ($r = .511$, $P < 0.001$), with the null hypothesis being that there was no correlation between quality of life and mobility.

Secondly, the Prosthetic Limb Users Survey of Mobility (PLUS-M) is designed to measure mobility.[2] The PLUS-M is a self-reported measure in which individuals rate the level of difficulty they experience across 12 different mobility tasks.[2] A positive correlation was also seen with general satisfaction and mobility ($r = .475$, $P < .001$).[1] Both of

these surveys show statistical significance ($P < 0.01$) which indicates that mobility is important to QoL and general satisfaction of amputee.

The level of limb amputation has also been found to affect the quality of life as BKA patients have been found to have higher quality of life ($p<0.05$) and functional independence ($p<0.0001$) than AKA patients.[4] Functional independence measure utilizes motor and cognition levels of patients to assess their disability in response to medical intervention.[5] When compared to AKA, limb salvage surgery (LSS-distal femur or proximal tibia amputation) has been found to have better gait efficiency and return to normal living as LSS patients were found to have a higher physiological cost index scores ($p=0.021$) and Reintegration to Normal Living Index ($p=0.032$). However, perceived quality of life was the same between the two groups as the Toronto Extremity Salvage scores ($p=0.051$) and SF-36 scores ($p=0.176$) showed no statistical significance.[6] Although QoL may not differ between the level of amputation, the articles underscore how level of amputation affects mobility. When compared to AKA, LSS has better gait and return to normal living.

Employment

Globally, many forms of employment require erect posture, ambulation, or driving vehicles. On a physical level, these can be very challenging for individuals with lower limb amputations. Sinha examines the relationship of employment differences between lower leg amputees and general populations ($n= 605$) in his research comparing lower QoL in amputees versus general population.[7] Specifically, the research highlights how employment was statistically lower ($P < 0.001$) for amputees compared to the general population.[7]

A 2018 study by Journeay describes how amputee patients ($n = 147$) did not show statistical difference in return to work when analyzing different causes of amputation (trauma vs non-trauma).[8] However, the level of amputation, BKA vs AKA, did show statistical significance ($p < 0.05$) with BKA patients more likely to return to work than AKA patients.[8] Thus, the level of amputation may be a more valuable predictor than the cause of amputation with regard to employment.

Self-Perception

Self-body image may also contribute to an amputee's overall QoL. Holzer analyzes the impact of lower-limb amputations on aesthetic factors: body image, self-esteem, and SF-36 to measure QoL[9]. Amputees had significantly lower ($P <.001$) scores when compared to the general population by the Multidimensional Body-Self Relations Questionnaire.[9] Secondly, amputees had lower SF-36 survey scores compared to the general population ($P < 0.001$).[9] However, the, Rosenberg Self-esteem (RSE) scores were not statistically significant ($p = 0.36$).[9] Thus, the effect of self-perceptive factors on QoL is uncertain, as body image and QoL are lower for amputees, but self-esteem is not statistically different.[9] As a result, focusing on improving body image of amputee patients may improve QoL.

Finally, Imeni researches the effects of spiritual care on the patient's perception of self-body image and overall QoL. This study ($n= 54$) compared two groups (experimental vs control) of amputee patients and added meditation intervention into the daily routine of 28 amputee patients (experimental).[10] Prior to meditation, no significant differences in mean score for body image ($t = 0.36$, $p = 0.72$) were found between both groups.[10] After implementation of meditation in the experimental group, mean body

SF-36 Survey Score by Researcher for Lower Leg Amputees						
SF-36 Score		**Sinha[6]**	**April[11]**	**Knezevic[12]**	**Hisam[13]**	**Suk Son[14]**
Physical Component Score	Physical Functioning	67.4	39.5	40.2	34.7	32.3
	Role Playing	48.7	37.5	25.9	33.9	40.1
	Bodily Pain	27.2	35.2	49.5	41.2	58.6
	General Health	23.6	44.8	50.1	48.2	45.5
Mental Component Score	Vitality	21.8	45.8	38.1	52.6	45.0
	Social Functioning	67.6	52.5	48.6	38.6	63.8
	Role Emotional	50.0	33.3	56.9	36.9	53.0
	Mental Health	70.4	52.7	62.1	43.4	58.6
Physical Component Summary Score (Avg)		41.7	39.3	41.4	39.5	44.1
Mental Component Summary Score (Avg)		50.3	44.7	49.4	42.2	52.9
Correlation Coefficient between MCS & PCS		**R = 0.94**				

Table 1*: SF-36 scores by individual categories from assorted researched on lower leg amputees in order to show the strong positive correlation between MCS and PCS.*

image disturbance was significantly lower compared to the experimental group prior to intervention ($t = 11.83$, $p < 0.001$).[10] There was also a significant difference between the experimental group and control group after the implementation of meditation ($t = 3.41$, $p = 0.001$).[10] Thus, emphasizing meditation in patients following an amputation can have a positive impact on the overall quality of life in this population.

Methods

This research looked at five studies that incorporated lower leg amputee patients. The majority of patients were below-the-knee amputees, which is consistent with real world evidence. Each study published results for individual components of the SF-36 survey (Table 1). From there, the eight individual components were averaged across two categories: the Mental Component Score and the Physical Component Score. The averages for each component are outlined on Figure 1. The analysis utilizes a simple linear regression model to compare the two categories. A correlation coefficient (r) was calculated.

Results

A correlation coefficient (r) = 0.94 was found. This indicates a strong positive correlation between the Physical Component Score and the Mental Component Score in the SF-36 survey.

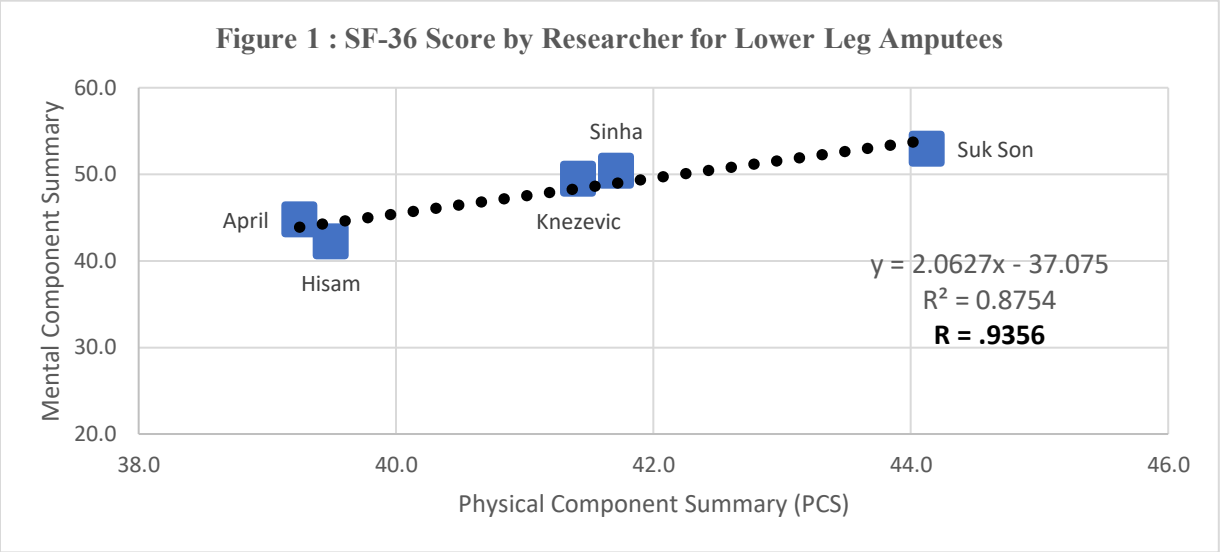

***Figure 1**: An analysis of 5 different studies incorporating SF-36 on patients with lower limb amputations, highlights there is a correlation between MCS and PCS of the SF-36[7,11,12,13,14].*

Discussion

The research looked at the effects of mobility, employment, and self-perception on the QoL of amputees. A positive correlation was found with quality of life and mobility in lower limb amputees that utilized prosthesis. General satisfaction and mobility were also found to be correlated.[3] Level of limb amputation was also found to affect QoL as higher quality of life and functional independence was seen in BKA patients compared to AKA patients.[4] When compared to AKA, limb-salvage surgery (LSS) patients were found to have better gait efficiency and return to normal living.[6] Employment research on amputees has shown that decreased employment for amputees leads to lower QoL compared to the general population.[7] However, BKA patients were found to have shorter return-to-work times compared AKA patients, showing a key difference within amputee groups.[8] Also, employment research on amputees has shown that decreased employment for amputees leads to lower QoL compared to the general population.[7] Meanwhile, BKA amputees have shorter return-to-work times than AKA amputees.[8] Self-body perception in an amputee's healthcare regimen may benefit QoL via incorporation of meditation[10].

Finally, measuring the QoL has generally been achieved through the SF-36 survey components of PCS and MCS. When performing a meta-analysis of five studies on lower limb amputations and SF-36, a proxy for QoL, there appears to be a strong positive correlation between the MCS and PCS. This shows

how the MCS and PCS influence each other, an important consideration for lower limb amputation rehabilitation program.

The study comprised on research articles on lower limb amputations. The majority of articles had more BKA patients than AKA patients (Figure 2). For future research, equal representation would be beneficial to better understand if differences exist between the two major types of limb amputations. In some cases, such as employment, differences between AKA and BKA patients were statistically significant, but further research is necessary to elucidate differences across mobility and body image. This would lead to better understanding of differences in QoL between the two groups and improve rehabilitation programs for amputees.

Conclusion

Since mobility, employment, and body image have shown to have effects on QoL, these factors must be addressed when a patient is receiving or has had an amputation. Because mobility has been found to be related to greater quality of life and general satisfaction, an emphasis should be placed on prosthesis rehabilitation to maximize mobility. Patient education for life after amputation should be emphasized both prior and after surgery so that they can maximize their quality of life. In order to further support this goal, BKA should be performed whenever possible over AKA so that patients can have greater functional independence and be employed if they prefer as BKA patients were found to have a shorter return to work time when compared to AKA patients. Emphasizing meditation in an amputee's healthcare regimen may help increase self-body image and overall QoL. Encouraging and implementing meditation in the daily routine of amputees may help strengthen self-body image and overall QoL. Given that the meta-analysis results reveal that emphasizing mental health can positively impact physical health, rehabilitation of amputees should improve both the physical and the mental aspects of treatment.

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Risk Factors for Birth-Associated Femoral Fractures in Neonates

Kaori Morimoto[+], B.A., Wendi Wu[+], MPH, B.A., Kristina Nagai[+], B.S., and Merna Labib[+], B.S.

[+]Western University of Health Sciences, College of Osteopathic Medicine of the Pacific-Northwest

ABSTRACT

Objective: This study aims to identify variables that increase risk of birth-associated femoral fractures and to explain the mechanisms of injury underlying these factors before and during delivery. Furthermore, this study analyzes which of those variables are associated with an increase in the risk of diaphyseal femoral fractures, the most frequently cited femoral fracture type in primary literature.

Methods: A systematic review of primary articles was conducted using eleven medical journal search engines. A total of 95 cases of neonatal femoral fracture were gathered from reports between the years of 1927 and 2018. The prevalence of risk factors found in the literature, such as method of delivery, position in utero, sex, birth weight, and gestational age were compared to the national prevalence for all births in the United States. Furthermore, statistical analysis was used to assess any relationships between risk factors and fractures.

Results: The prevalence of female sex, breech presentation, and Cesarean delivery among the reported cases of birth associated femoral fractures were remarkably higher than that of the national average in the United States. On the other hand, the prevalence of prematurity and fetal macrosomia grade I among the cases were higher than the national average. The statistical analysis suggests that male sex, prematurity, and fetal macrosomia have higher odds for birth-associated diaphyseal femoral fractures over any other fracture site in neonates while Cesarean delivery of fetuses in breech presentation may reduce the risk of diaphyseal femoral fractures. However, those findings were not statistically significant.

Conclusions: Our results support the current knowledge of the Cesarean section and breech presentation in utero and that they contribute to the increased risk of birth associated femoral fractures. However, our results indicate that most of the neonates were in the normal weight range and 65% of the cases were female as compared to previous studies. Furthermore, a larger sample size is needed to determine statistically significant risk factors for site specific fractures in further studies.

Introduction

Birth related long bone fractures are rare, 0.13 per 1000 live births, when compared to other types of birth injuries such as cephalohematoma related injuries or brachial plexus injuries.[1,2, 3] The femur is the fourth most common birth associated fracture site following fractures of the clavicle, humerus and cranium.[4] Due to the rarity of birth associated femoral fracture cases and limited literature reports, there are no established maneuvers to reduce the risk of such cases.[5]

The identification of risk factors is key to a better understanding of birth related femoral fractures. For instance, long bone fractures were more frequently associated with breech Cesarean deliveries as compared to vaginal deliveries.[6] Other potential risk factors associated with femoral fractures include complicated deliveries, small and large fetuses, premature births, twin pregnancies, breech presentation, and fetal osteoporosis[1].

This study aims to assess the potential risk factors associated with neonatal femoral fractures by analyzing 95 fracture-related case studies. The study also analyzes the association of risk factors in femoral diaphyseal fractures. In doing so, this systematic review aims to aid the development of preventative maneuvers that can potentially improve outcomes.

Study Design

The following 11 major medical literature search engines were used from the dates of the articles included until August 11th, 2018: Pubmed, Google scholar, Embase, PMC, Europe PMC, CINAHL, Cochrane Library, MeSHMEDLINE, Ind Med, ERIC, and ProQuesti.

Inclusion criteria for this analysis encompassed the discussion of neonatal femoral fracture associated with labor and required information regarding birth weight, position in utero and method of delivery.

Studies were excluded if the fracture occurred during the prenatal period, the fracture occurred after the neonate was born and not labor associated, or the fracture site is not in the femur. 33 articles describing 95 cases of femoral fractures met the criteria for the study.

The following information was collected from studies that met the inclusion criteria for data analysis: the site of the fracture(s), sex, gestational age, birth height, pre-existing condition of neonates, singleton/ twin/ triplet or more, maternal parity, maternal age, maternal medical history, details of the

pregnancy, details of delivery, and medical provider title (physician, resident, midwife etc.), Apgar score, age of diagnosis, radiographic degree of dislocation on anterior-posterior and lateral view, treatment method, outcome, the neonate's age at the final follow-up, maternal accessibility to medical service, maternal socioeconomic status, and maternal race. International articles and studies were translated and incorporated.

Five variables of interest were identified for further statistical analysis: method of delivery, breech presentation in utero, sex of neonates, fetal macrosomia grade I, and prematurity. These variables were chosen because they represented the most complete and consistent measures among the cases. Variables were coded dichotomously as the following; position in utero: breech or non-breech presentation, method of delivery: Cesarean section or vaginal delivery, birthweight: <4000 grams or grade I fetal macrosomia, between 4000 grams and 4499 grams, and prematurity: gestational age <37 weeks or ≥37 weeks. The data was statistically analyzed using Statistical Analysis Software (SAS).

Results

Among the 95 cases of birth associated neonatal femoral fractures, 85 observations were infants and 10 cases had bilateral fractures. Cesarean deliveries consisted of 77.3% of the cases while 22.7% were delivered vaginally. Breech presentation was seen in 75.0% of the cases and 19.4% presented in the cephalic position. Fracture was more prevalent among female neonates and 64.9% of the birth-associated femoral fractures were observed in female neonates, compared with 35.1% in males. The mean birthweight was 2901.67 grams with a standard deviation of 772.43 grams. The average gestational age was 36.84 weeks with a standard deviation of 3.69 weeks. The median gestational age was 38 weeks.

Out of the 95 cases, 75 cases reported the site of fracture. 55 (73.3%) fractures were diaphyseal, 8 (10.7%) were metaphyseal, 6 (8%) were subtrochanteric, 5 (6.7%) were epiphyseal, and 1 (1.3%) was physeal (Figure 1). Variables were ealuated on their potential relationship to diaphyseal fractures as the diaphysis was the most common fracture location by a significant margin.

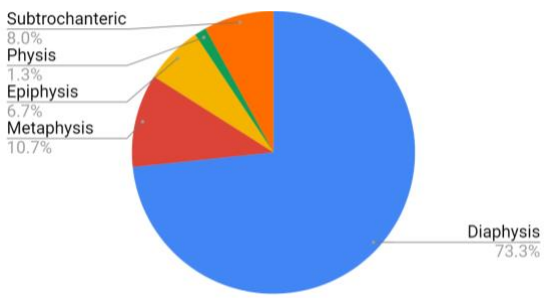

***Figure 1**: Sites of femoral fracture, N = 75*

Variables	Sample Size	Odds Ratio	95% Confidence Interval	Chi-square or Fisher's Exact p
Cesarean delivery	37	0.27	(0.06, 1.32)	0.1254
Breech position in utero	32	0.5	(0.09, 2.63)	0.7084
Gender (Male)	16	1.73	(0.48, 6.2)	0.3327
Fetal Macrosomia	52	3.06	(0.56, 16.6)	0.3944
Prematurity	21	1.44	(0.48, 4.33)	0.5139

***Table 1**: Relationships of variables with diaphyseal femoral fractures compared to other sites*

The data showed that breech position and cesarean delivery were less indicative of diaphyseal fractures compared to breech position and vaginal delivery. Newborns presenting in breech position in utero had 0.5 times the odds of developing a diaphyseal femoral fracture than newborns in transverse, cephalic, and oblique positions with 95% confidence intervals of 0.09 and 2.63. Babies delivered via cesarean section had 0.27times the odds of diaphyseal fracture compared to other fracture sites than those delivered vaginally with 95% confidence interval of 0.06 and 1.32. On the contrary, babies characterized by fetal macrosomia, male sex, and prematurity (gestational age < 37 weeks) had higher chances of diaphyseal fractures over epiphyseal, metaphyseal, physeal, and subtrochanteric sites. Neonates weighing between 4000 grams and 4499 grams (grade I fetal macrosomia) had 3.06 times the odds of diaphyseal fractures than other fracture types compared to neonates weighing less than 4000 grams with 95% confidence interval of 0.56 and 16.6. There were no reported birth associated femoral fracture cases in

neonates with fetal macrosomia grade II (between 4500 grams and 4999 grams) and grade III (over 5000 grams). While the overall fractures were more prevalent in female neonates, male babies had 1.73 times higher chances of diaphyseal fractures compared to female babies with 95% confidence interval of 0.48 and 6.2. Finally, prematurity, defined as being born at less than 37 weeks of gestational age—resulted in 1.44 times higher odds of diaphyseal fractures compared to those not born prematurely with 95% confidence interval of 0.48 and 4.33.

Chi square and non-parametric, Fischer's exact tests as well as 95% confidence intervals for odds ratios did not indicate statistical significance between variables of interest and fracture site (all $p > 0.05$, 95% CI contained null value of 1). This is likely due to small total sample size (n) and disproportionately higher prevalence of diaphyseal cases compared to all other fracture sites.

Discussion

Method of delivery, fetal position in utero, sex of the neonates, birth weight, and gestational age are discussed in this section as risk factors for the birth associated femoral fractures in neonates. In addition to this, the risk factors for the femoral diaphyseal fractures were analyzed. Lastly, the impact of comorbid congenital pathologies on the risk analysis of the birth associated neonatal femoral fractures is discussed.

Method of Delivery

This study revealed that 77.3% of deliveries were Cesarean section, while previous studies have shown that 32.9% of the deliveries in the United States in 2016 were Cesarean deliveries.[7]

Morris et al. reported in 2002 that femoral fractures were mainly spiral fractures caused by a torque force applied during difficult extraction.[1] Investigating why such large torsional forces were applied to the neonatal femur during Cesarean deliveries is a complicated task. This could be due to the lack of alternative maneuvers for difficult extraction during Cesarean delivery, pre-existing conditions such as osteogenesis imperfecta, or inadequate operator skill.[5,6]

Generally, fractures occur when a bone is exposed to forces beyond its energy-absorbing capacity, which is determined by material properties and geometries of bones such as size, shape, and curvature.[8] If the kinetic energy exceeds the bone's elastic limit, fracture can occur.[2,4] Of all the types of fractures, a torsion fracture is the most complicated. A material under torsional force experiences shear stress on perpendicular and parallel planes maximally to the neutral axis, which is the hypothetical axis that runs in the middle of the cylindrical model. At the same time, maximal tensile and compressive stresses are generated perpendicular to each other and both diagonally to the neutral axis. The net effect of those forces results in a spiral fracture of long bone.[9]

Giving the mother adequate analgesia, avoidance of using overzealous traction, and extension of the uterine incision are commonly used methods to reduce the occurrence of birth injuries during Cesarean sections.[5] Utilization of these methods will reduce the difficulty in extraction and prevent the application of excessive torque force on femurs of neonates during Cesarean deliveries.

Fetal Position in Utero

This data shows that 75.0% of the neonates who had birth-associated femoral fractures were in breech presentation in utero. In the general population, breech presentation is more common in the earlier stage of gestation. Approximately 24% of fetuses are in breech presentation at 28 weeks of gestation, but by 37 weeks of gestation, only 3.7 % are in breech presentation.[10]

It is difficult to separate breech presentation and Cesarean section as risk factors since 90.9% (50 out of 55 cases) of neonates in breech presentation were delivered via Cesarean section. Planned Cesarean delivery between 39 and 41 weeks of gestation is highly recommended to reduce the risk of complications for fetuses in breech presentation.[11] Berhan et al. reported that relative risk of perinatal mortality and morbidity of neonates in breech presentation delivered vaginally was two to five-fold higher than that of neonates in breech presentation delivered by planned cesarean sections.[12] Considering that Cesarean section is one of the most routinely used methods for breech delivery, it makes sense that those risk factors coexist in many cases for this study.

Sex of the Neonates

Our data suggest that 64.9% of the reported birth associated femoral fractures in newborns were in females. Sex has been a researched risk factor for fractures, however, there is limited literature explaining the role of biological sex in birth related femoral fracture in neonates.

Multiple literature specifies that in pediatric populations, male newborns had higher incidence of femoral fracture than female newborns.[13,14] This could be due to a clear difference between female and male bone structures. For example, a study of adolescent males and females suggested that males have greater bone mineral content in femoral head and total femur in addition to higher bone mineral content and bone cortical density at the hip and distal tibia after correcting for body size.[15]

Differences in sex hormones in males and female explain the higher incidence of birth associated femoral fractures in female neonates. Sex steroids such as testosterone and estrogen have important role in maintaining bone health. Testosterone, specifically, increases radial growth while estrogen decreases periosteal bone formation.[16] This contributes to the higher periosteal bone formation and higher bone strength in male.[17] Males begin producing testosterone at seven weeks of gestation and maintain a high level throughout most of the second and third trimester, reaching up to 300 ng/dL.[18] At birth and during most of the prepubertal period, male testosterone level is only slightly higher than that of females. However, there will be a marked difference between male and female in serum testosterone levels both during and post puberty.[19] Sex-associated factors such as hormones, that affect bone mineral content and density, may account for the differences in fracture risk.

Birth Weight

The mean birth weight of neonates with birth related femoral fractures was 2898.69 g with standard deviation of 579.83 g, which is within the range of normal birth weight (2500g - 3999g). Additionally, 7.37% of our cases weighed less than 1499 grams, and 14.74% of our cases weighed between 1500 g and 2499 g.

Low birth weight is a possible risk factor for birth related femoral fractures. Very low birth weight (VLBW) is defined as neonates weighing less than 1499 grams and moderately low birth weight (MLBW) is defined as neonates weighing between 1500 grams and 2499 grams.[7] 1.40% of infants born in the US in 2016 had VLBE and 6.77% had MLBW.[7]

Fetal macrosomia is defined as grade I (4000g - 4499g), grade II (4500g - 4999g), and grade III (>5000g).[20] Approximately 9% of newborns in the US fall in one of those categories.[21] Out of our 95 cases of femoral fractures in our study, 6.32% fell into the category of grade I fetal macrosomia. Furthermore, the heaviest neonate with birth associated femoral fracture, whose record was available was 4270 g.[22]

One potential reason for the lower average weight in our sample compared to that of the general population in the US could be due to differences in racial distributions among the two. Our study includes cases from Europe, Middle East Asia, East Asia, and South America in addition to the US. Additionally, there were no literatures of birth associated femoral fractures in neonates who could be categorized as grade II and III fetal macrosomia. Due to the low incidence of femoral fracture compounded with the low incidence of femoral fracture among fetal macrosomia, it was difficult to conclude fetal macrosomia is a significant risk factor.

Gestational Age

The mean gestational age of neonates with birth related femoral fractures was 36.84 week with a standard deviation of 3.69 weeks. The median was 38 weeks. Prematurity is defined as birth with less than 37 weeks of gestation.[23]

Premature delivery of neonates may implicate biological processes that influence the likelihood of fractures. Prematurely delivered babies have a shorter time frame during which they can receive calcium, phosphorus, and magnesium from the mother, leading to increased risk for femoral fractures. After 24 weeks of gestation, the rate of maternofetal calcium, phosphorus, and magnesium transfer increases dramatically. Two-thirds of total body calcium, phosphorus, and magnesium accumulates after 24 gestational weeks as well as 30 g of calcium is transferred to fetus during the third trimester.[24] Thus, prematurity would lead to weaker bone structure where 70% of the bone consists of inorganic matter and hydroxyapatite.[25] This may be why prematurity is one of the possible risk factors for the birth associated femoral fractures in neonates.

Risk Factors for Diaphyseal Fractures

A total of 73.3% of all the cases selected for this review were diaphyseal fractures (Chart 1). Additionally, our analysis suggested that prematurity and grade I fetal macrosomia may increase the risk of diaphyseal femoral fractures compared to full term neonates and normal or low birth weight neonates. On the other hand, breech position, Cesarean deliveries, and female gender were less indicative of diaphyseal femoral fractures compared to non-breech neonates, vaginal deliveries, and male gender, respectively.

While discussing the bone biomechanics of the diaphysis as opposed to other femoral sites, the differences between adult and neonatal bones must be made clear. In adult bones, the maximal hardness of the femoral shaft is located at the distal region and decreases along the proximal region.[26] On the other hand, the bones of infants, especially immobile infants who are not weight bearing yet, have smaller bone size, reduced mineralization, and reduced stiffness. These characteristics make infant bones more susceptible to incomplete fracture such as greenstick fractures.[27]

Difference in chondrocyte activity and chondrocyte arrangement patterns at the various femur sites can serve as a determining factor for where torsional forces are applied. In the pediatric

bone, there is an increase in chondrocytes at the epiphysis, metaphysis, and a portion of the diaphysis closer to the ends of the femur.[27] Postnatal and fetal femurs have the same chondrocyte pattern, which is a straight columnar layout and advances from the epiphysis towards the mid-shaft.[28] This may contribute to higher diaphyseal fracture rates in those populations.

Discussion of Comorbid Congenital Pathology as a Risk Factor

It is worthwhile to mention that the data includes neonates with preexisting medical conditions. There were 3 cases of osteogenesis imperfecta, 8 cases of arthrogryposis, 4 cases of myelomeningocele, 1 case of neuromyopathy, 2 cases of Noonan syndrome, and 2 cases of spina bifida.

Osteogenesis imperfecta affects the bones rather globally than locally. Approximately 80% of osteogenesis imperfecta is caused by an autosomal dominant mutation in type I collagen genes (*COL1A1* and *COL1A2*) that weaken the tensile strength within the bone.[29] Due to the collagen defects, there is inadequate ultimate stiffness, load, and displacement of the *whole bone* in patients with osteogenesis imperfecta, resulting in higher fracture risk.[8] Thus, we have included patients with osteogenesis imperfecta, assuming a similar mechanism of injury as it occurs in healthy fetuses.

Arthrogryposis multiplex congenita is a disorder characterized by non-progressive, multiple contractures that are caused by congenital abnormalities and pregnancy complications such as oligohydramnios.[30] Since the fetal movement which starts at about 8 weeks of gestation is essential for proper fetal growth, any intrinsic and extrinsic causes that hinder fetal movement can potentially lead a fetus to have various degrees of contracture.[31]

There was no literature found which discussed increased risk in birth- associated fractures due to arthrogryposis, myelomeningocele, neuromyopathy, Noonan syndrome, or spina bifida. Moreover, there was no literature found which mentioned those conditions requiring different maneuvers for vaginal and Cesarean delivery. Paying attention to further research about those conditions and the associations of those conditions with birth related injuries are essential to reassure the accuracy of our results.

Conclusion

This study aimed to investigate how certain factors of fetal development and birth might increase the risk of femoral fractures at different areas of the femur. Cesarean delivery, breech presentation, and female sex appear to be associated with higher risk of birth-associated femoral fracture overall, whereas the effects of birth weight and gestational age were unclear among cases found in the existing literature.

This study also suggests that prematurity and grade I fetal macrosomia may increase the risk of diaphyseal femoral fractures while breech position, Cesarean deliveries, and female gender were less indicative of diaphyseal fractures in comparison with other femoral fracture sites.

Further research using cohort study designs and hospital datasets on this topic would give us additional valuable insights.

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Utilizing Gait Abnormality as a Tool for Early Diagnosis of Autism in the Pediatric Population

Wendy P. Lewis[+], B.S., and Brianna N. Grant[+], MScPh

[+]Western University of Health Sciences, College of Health Sciences

ABSTRACT

Objective: This article aims to inform clinicians that they can begin to look for abnormalities in the gait of pediatric patients and use them as tools to support a diagnosis of autism spectrum disorder (ASD) at earlier ages.

Method: The keywords gait, abnormality, variability, and autism produced 100 peer-reviewed articles for review from online databases. Articles were excluded if they discussed other disorders as the cause for gait abnormalities or were published before 2009.

Results: When compared to controls, children with autism displayed asymmetrical crawling, and variabilities to normal gait: lack of balance, consistency and smoothness, and skipping or non-purposeful movements. Most notable is an increased stride length, cadence and step-width and decreases in range of motion in the ankle and hip while flexing.

Conclusion: Clinicians should use a simple visual assessment looking for changes in gait: jumping, hopping, skipping and spinning are considered restrictive or repetitive styles of walking. Detection of these gait abnormalities allow early diagnosis and earlier referral.

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder, which includes the main symptoms of impairments in social communication and repetitive behaviors.[1] In this literature review, we discuss an important core symptom: motor dysfunction. In children with ASD, delays in their developmental milestones, as compared to other children in the same age group, are observed.[2] Some delays include impairment in sitting, crawling, walking, coordination, gross and fine motor functions, and increased proprioceptive input needs. Even with awareness of these delays and acknowledgement of a motor skill deficiency, our search found a lack of discussion focused on appropriately identifying the problems and correcting them. An early diagnosis is imperative because it allows the clinician and parent to take advantage of the delicate period of rapid age-related change where children with autism may fall behind. These include social behaviors, cognition, and communication.[2] Children can be referred for occupational therapy, physical therapy, applied behavioral therapy and/or speech therapy. Studies have shown that these therapies have improved outcomes in ASD, namely, improvements in attention skills, expressive language and parent-child interactions were observed.[3]

As a child develops, there are certain milestones that are expected to be reached at certain months of age. By 5 months, a typical child begins standing with assistance. The child is able to stand alone at about 7 months and begins walking unassisted at the average age of 9.5 months.[4] In children with autism, there is an average age for onset of walking between 14-16 months.[5] Apart from the delay in time, differences are also seen in the actual gait patterns. Infants without autism have coordinated gaits with normal strides and purposeful movements, whereas the opposite is seen for infants with autism. Children with ASD lack the consistency, smoothness and coordination as compared to children without the disorder.[1]

When assessing gait, the following parameters should be noted: temporal and spatial, kinematic, and kinetic.[6] Temporal and spatial relate to the time and distance in regard to the speed of gait, the timing of the stride, and the length of the stride. Kinematic consists of the way in which the body moves without relation to causes of motion. Kinetic refers to the force that is required to yield movement. Although all are essential when analyzing gait, the biggest factor is ground reaction force, which is simply the force that is exerted by the ground onto the foot.[6]

Visual Assessment

A visual assessment at well-child visits can help clinicians identify abnormalities in their patients at any age. It is important to observe smoothness, balance and coordination in the child's gait (Figure 2). In children with ASD, movements are un-purposeful; jumping, hopping, skipping and spinning are considered restrictive or repetitive styles of walking.[7] It is also important to take the child's age into consideration. A recent study conducted in 2017, by Ammann-Reiffer et. al, found that in all children, gait variability decreases as the child gets older.[8]

Being able to accurately and visually evaluate gait abnormalities or variability in a child, will lead to an earlier diagnosis of ASD, which results in earlier referrals needed for intervention.

Figure 1: *Asymmetrical crawling, preference of one side over another in an 11-month old, who was later diagnosed with ASD. Original image taken by mother, Wendy Lewis, PA-S2.*

Methods

Pumerantz Library, PubMed, Google Scholar, EBSCOhost, and ERIC databases were searched. Also, the reference section for relevant articles found provided additional resources such as Science Direct, European Journal of Paediatric Neurology, Journal of Autism, BMC Pediatrics and Developmental Disorders. The main keywords utilized for the purpose of this paper were "gait abnormality in autism," "autism motor dysfunction," "gait variability in autism," and "treatment of gait in autism" which resulted in 100 articles. Exclusion criteria for this analysis consisted of any documentation of abnormalities in gait that were explained by disorders or diseases other than autism. Articles written as follow-up to previously published research did not provide new information and were therefore excluded. Articles published before 2009 were excluded. Finally, 11 articles were used for this article.

Results

A study, conducted by Bishop et al. (2016), focused on associating lower IQ with increased rates of late walking with ASD and non-ASD groups, which included intellectual disability (ID). The low IQ corresponded to the difference between walking parameters in those with ID versus ASD; children with lower IQ and an ID, were more likely to show a delayed walking schedule as compared to those with ASD alone.[5] While this study focused on comparing ASD to low IQ and how they affect gait, a study conducted by Calhoun et al. (2011) focused on comparing the kinematic and kinetic gait patterns of ASD children versus normally developed children. The results focused on significant decreases in range of motion found in two joints: the ankle and the hip, and only while flexing.[9] These abnormal walking patterns leads to pain, fatigue, and joint stress which then leads to a problematic quality of life.[10]

Research conducted in 2011, by Esposito et al., aimed to prove that there was a correlation between early motor dysfunctions in autism by video recording children with ASD, children with non-autistic developmental delays, and children with typical development ranging from 3 to 5-years old.[10] These recordings demonstrated asymmetry which they believe is linked to the atypical hemispheric asymmetry or disturbance of brain connectivity that defines early autism

While the previous study conducted by Esposito et al., discussed symmetry versus asymmetry, another study conducted in 2017, by Hasan et al., focused on the 3D ground reaction force.[6] This study revealed that children with ASD have impairments in their ground reaction force gait patterns in the anterior-posterior and vertical direction during stance phase.[6]

Discussion

Bishop et al. (2016) compared and contrasted the onset of walking of children with ASD alone or children with ASD and ID. Lower IQ scores in both the ASD and non-ASD group demonstrated that these scores played a role in increased rates of late walking. Even though this was the case, the findings demonstrated that children with low IQ in the absence of ASD were more likely to show delayed walking. This illustrates that further research regarding separate etiological pathways to ID in children with and without ASD need to be sought out.

Calhoun et al. (2011), contrastingly, brought the attention from noticing there was late walking associated with ASD to focusing on distinguishing gait patterns once the child starts walking. The researchers centered the attention around observing the increased stride length, cadence and step-width in children with ASD. These differences are presumably due to the need for balance and stability caused by a child with ASD being challenged by proprioceptive deficiencies. While the authors focused on the kinematic and kinetic gait patterns, they were able to locate the reasoning associated with the decreased ground reaction force (GFR) that is seen in ASD. With the decrease in range of motion mentioned in

results of this research, there is a correlation with possible weakness in the flexor muscles that also reduces plantar flexion during the toe-off part of walking and in the force from the hips when taking a step, which both decrease GFR. Thus, the more severe the reduction, the more lack of coordination is evident. Once there is a clear understanding of the movement patterns in children with ASD, intervention strategies will be implemented to advance and assist in the motor skill acquisition and at the same time minimize, or even eliminate, movement deficiencies.

Esposito et al. (2011) focused on the "why" that is seen in the variability of gait seen in children with ASD. It has been mentioned that delayed walking has been observed in ASD, followed by the observation of walking in children with ASD. These researchers, Esposito et al., discusses the observations noted during video recordings that were measured with the walking observation scale, positional pattern for symmetry during walking, static symmetry, and dynamic symmetry. After complete analysis of all specific guidelines that were set for the evaluation, researchers identified differences in gait patterns in the children with autism as opposed to the control group. The main difference was asymmetry noted during gait, which was also noted in infants with autism in the lying position, as well as with crawling (Figure 1). The authors ended the research by noting that this asymmetry could be the actual expression of the atypical hemispheric asymmetry or disturbance of brain connectivity that defines early autism. This postural asymmetry that is perceived aligns with the suggestion that implicates cerebellar involvement in the motor symptoms of autism. This could be a very useful diagnostic tool, not only for autism itself, but for gait abnormalities and possible need for treatment later in life.

In the study conducted by Hasan et al. (2017), the main focus was to explain what occurs during walking, in children with ASD, that causes asymmetry. There are many components to walking that should be at lower or maximum force but in children with ASD, the norm is altered. In the first half of the stance phase of gait, there is a braking force that is needed to decrease the body center of mass. This specific part of stance is important for the preservation of limb movement. In children with ASD, there was a maximum braking force which alters stability and shock absorption. Apart from the initial stance phase of gait, children with ASD were also found to have reduced the second peak of vertical GRF in the terminal stance. The coupling of difficulties in the first half of the stance phase of gait and terminal stance of gait causes a struggle in supporting their body weight. All of these findings combined contributes to what we observe as asymmetry during gait.

The results of these many articles, as compared and contrasted above, demonstrates that there are a lot of factors that need to be considered when observing gait abnormalities in children with ASD. It is important to understand that late walking is not only appreciated in ASD but as well as children with low IQs and IDs. Apart from identifying that a child is late with their onset of walking, there are observations that can be made, whether it be asymmetry in gait, the kinematic and kinetic patterns or the mere lack of coordination, that can help identify a young child with ASD. The findings of these research are useful to the clinicians and the parents of these children to ensure appropriate diagnosis at earlier stages in life which then will lead to appropriate treatments and rehabilitation programs.

F*igure 2:* *Authors assess gait in the same child as Fig. 1. Now 9-years old, he demonstrates uncoordinated moves. Original image taken by mother, Wendy Lewis, PA-S2.*

Treatment

A conservative approach is preferred in mild cases because of the notion that gait variability usually resolves as the child ages.[8] Early assessment and intervention should be individualized to include muscle strengthening as the key therapy. Physical therapy programs should incorporate the areas of balance, gait reeducation, and proprioception, but especially in strengthening flexor muscles of hips and ankles, for maximal results.[9] Few studies have been conducted on the use of occupational therapy and pediatric neurorehabilitation. However, robotic assisted gait training (RAGT) is currently being studied for children with cerebral palsy and would require further research in children with ASD.[8] A multidisciplinary team should be recruited in the treatment of ASD and in treating motor deficiencies. The general focus should be on increasingly

challenging the child to walk, run and play without the need to increase stance-width, as well as giving the child confidence.

Conclusion

Although current published research focuses mostly on ASD as the diagnosis, this paper aims to help clinicians understand that identification of a gait disorder can help in diagnosing ASD at a much earlier age. Articles such as *Gait Patterns in Children with Autism* elaborate on looking at the various possibilities for early recognition that have non-conventional, but accurate, approaches at identifying children with autism.[11] There is substantial supporting research concluding that a deficiency in motor development is the possible biomarker for autism.[10] Early therapy for children with ASD has shown to improve outcomes in the areas of speech, attention and interaction. The next step should be to utilize this knowledge to develop appropriate screening tools for identifying children with autism uniformly, on the basis of early gait variability and then referring for early intervention. Early therapy for children with ASD has shown to improve outcomes in the areas of speech, attention and interaction.

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Efficacy of Non-Surgical and Non-pharmacological Treatment of Pelvic Girdle and Low Back Pain in Pregnant and Postpartum Women

Madeleine Shaver[+], B.A. and Hana Hadiprodjo[+], B.S.

[+]Western University of Health Sciences, College of Osteopathic Medicine of the Pacific-Northwest

ABSTRACT

Objective: Evaluate current studies on osteopathic manipulative treatment, physical therapy, and exercises to treat pelvic girdle pain, low back pain, and back-function in pregnant and postpartum women.

Methods*:* Review of randomized controlled trials identified through PubMed, Science Direct, and JOAA from 2000 to 2019.

Results*:* Osteopathic manipulative medicine has been shown to alleviate pain and increase functional status in pregnant women. Physical therapy has also been shown to improve pain outcomes in both pregnant and postpartum women. The effect of physical exercise on pain outcomes, however, showed little to no effect on the prevention and treatment of pelvic and low back pain.

Conclusion*:* Our literature analysis shows adding osteopathic manipulative treatment to usual obstetric care may reduce pain and improve back-function for women with pelvic girdle pain and low back pain. Patient outcome was more variable in the physical therapy and exercise study. Further studies are needed to characterize the effectiveness of both OMT and exercises in alleviating and preventing pelvic girdle and low back pain in both pregnant and postpartum women

Introduction

Pelvic girdle pain (PGP) and low back pain (LBP) are both common complaints of pregnant and postpartum women. In a 2007 study surveying 599 low socioeconomic status women in the U.S., Skaggs et al. reported that nearly 67% of these women experienced some form of musculoskeletal pain, and that 85% of these women did not feel they had been offered effective treatment for their complaints. [1] A study by Weis et al. supports this conclusion, estimating that as many as 3/4 of women experience some form of pain during their pregnancy. [2] A review by Liddle et al. also supports that the likelihood of women experiencing low back or pelvic pain during pregnancy is high, estimating that between 24-90% of women experience some form of low back or pelvic pain during pregnancy. They additionally attribute this high variability to poorly defined classification for what constitutes each condition, indicating a lack of standardization for the definition of low back and pelvic pain. [3–5]

PGP is most often defined as pain associated with the pubic symphysis joint and/or sacroiliac joint.[6] Prevalence ranges depending on how the data is collected and defined. This musculoskeletal pain disorder often manifests during the anatomical changes of pregnancy and may or may not be accompanied by low back pain. Though most women will recover after birth, a percentage of women will have persistent PGP disorder. [7,8] A study by Croft et al. supports this, concluding that resolution of pain for women experiencing low back and pelvic pain during pregnancy is considered poor, with many women seen in the study still experiencing pain even 1 year after they initially presented with this complaint. [9] Currently, methods for both classifying and treating pelvic girdle and low back pain are poorly described. [3–5] In this review, we will analyze the effectiveness of osteopathic manipulative therapy, physical therapy, and other forms of exercise in patients with pregnancy related pain low back or pelvic pain.

Methods

Publications were identified using the search engine PubMed, Science Direct, and the JOAA. Key words used to identify publications included: “pelvic girdle pain,” “osteopathic manipulative treatment,” “non-surgical treatment of pelvic pain,” “postpartum pain,” and “prepartum pelvic pain.” Papers were included for review if they were randomized controlled trials. Studies were excluded if they were published before 2000 or did not meet the criteria of a randomized, controlled study or clinical trial. No limit was applied to patient number.

Results

Osteopathic Manipulative Treatment

Osteopathic physicians are specially trained with the philosophy that the body’s function and structure are interrelated. Therefore, their training emphasizes the ability to evaluate the

neuromusculoskeletal system and help restore normal body mechanism through what is called Osteopathic Manipulative Treatment (OMT).[10] OMT has been reported in various clinical studies and case reports to help with pain management. [11–13] However, only recently have OMT's effect on pregnancy-related pain been explored.

In 2010, Licciardone and colleagues evaluated 144 women for pain during their third trimester. Participants were divided into 3 groups: usual obstetric care and OMG (UOBC+ OMT), usual obstetric care and sham ultrasound treatment (UOBC+SUT), or usual obstetric care only (UOBC only). Women in the UOBC+OMT group would have received individualized osteopathic manipulative treatments that catered to each patient's unique somatic dysfunction, and may have included soft tissues, myofascial release, muscle energy, and range-of motion mobilization techniques. Women in the UOBC+SUT group received nonfunctional ultrasound therapy from an osteopathic physician. Though the ultrasound wand did not emit any waves, the machine did emit visible and auditory cues as a means for a potential placebo response. Lastly, all 3 groups received conventional prenatal care. Licciardone et al. captured participants response for back pain with a 0-10 pain scale and back-specific functioning with a Roland-Morris Disability Questionnaire (RMDQ). Results showed that there were no significant differences in pain reporting between groups: OUBC+OMT. However, there was significantly less back-specific functioning deterioration in UOBC+OMT group where effect size, calculated as changed in experimental group versus control divided by standard deviation of both groups, is 0.72 in comparison to UOBC only and 0.35 in comparison to UOBC+SUT group ($P<0.001$).[14]

A 2015 study by Hensel et al. expands the statistical power of Licciardone et al.'s 2010 study. They conducted a randomized, placebo-controlled trial on the effectiveness of OMT on 400 women in their third trimester for pain and back-related functioning, comprising one of the largest randomized placebo-controlled trial evaluating OMT to date. Participants were randomly assigned to one of 3 groups: usual care only (UCO), usual care plus OMT (OMT), or usual care plus placebo ultrasound treatment (PUT). Participants in the UCO group did not receive any additional treatment outside of standard obstetric care. Treatment included in the OMT group included seated thoracic articulation, cervical soft tissue treatment, occipito-atlantal decompression, thoracic inlet myofascial release, lateral recumbent scapulothoracic soft tissue, lateral recumbent lumbar soft tissue, abdominal diaphragm myofascial release, pelvic diaphragm myofascial release, sacroiliac articulation, pubic symphysis decompression, frog-leg sacral release, and compression of the fourth ventricle. Lastly, the PUT group experienced a procedure in which the ultrasound wand was placed in a specific area of the patient but did not emit any ultrasound wave. Measurement of pain was reported using the Quadruple Visual Analog Scale which averages the scores of four pain factors on a scale of 0 to 100. Back-related functioning was reported using the Rolannd-Morris Low Back Pain and Disability Questionnaire. They found that the OMT group had a better pain and functioning outcome than the UCO group ($P < 0.001$). However, OMT group was not significantly different from the PUT group which Hensel and colleagues argue could be due to the placebo effect.[15]

Physical Therapy and Exercise Treatment of Pelvic Girdle Plain

Several studies have explored the use of physical therapy exercises and exercise in the treatment of PGP and LBP in pregnant and postpartum women. A 2004 randomized-controlled clinical trial with stratified group design by Stuge et al. sought to evaluate the efficacy of a treatment program of specific stabilizing exercises for PGP in postpartum women. In their study, 81 women with PGP were randomized into two treatment groups for a 20-week duration. One group received postpartum physical therapy with a focus on specific stabilizing exercises while the other group received individualized physical therapy without the stabilizing exercises. The patients were assessed at baseline, after 20 weeks, and 1 year postpartum with both questionnaire and physical exam. Measurement criteria included pain, patient functional status, and patient quality of life following treatment. Results of the study indicated that patients receiving the specific stabilizing treatment showed a statistically significant improvement in difference in pain, disability, and quality of life compared to the control group. Exercises for each woman, regardless of their study group, were individually adapted and made following an individual examination. Consequently, each participant had individualized exercises, regardless of their study group. Stuge et al. conducted a 2-year follow up study of the aforementioned clinical trial and discovered that their initial findings persisted two years from the conclusion of the trial. [16,17]

Kordi et al. also sought to evaluate the efficacy of home-based pelvic stabilizing exercise in pregnant women experiencing pelvic girdle pain compared to treatment with a lumbopelvic belt. They conducted a randomized controlled trial consisting of

105 participants. Thirty-five women were assigned to a control group and received general information regarding anatomy, body posture, and ergonomics. Thirty-one women were assigned to the pelvic stabilizing-exercise group, and another thirty-one were assigned to the lumbopelvic belt group. Patients were assessed for pain intensity and functional status (measured with visual analog scale and the Oswestry Disability Index) as well as quality of life (measured with the WHOQOL-BREF questionnaire). The women were assessed at baseline, and then at 3 and 6 weeks. The women in the belt group were instructed to use the belt constantly unless they were sleeping. The women in the exercise group were prescribed a regiment of aerobic exercise of brisk walking for 25 minutes a day, 3 days a week; this was followed by stretching for 2 times a day, 3 times a week; strength exercises designed to stabilize the pelvis including forward bending, forward bending, back pressing, diagonal curling, upper body bending, leg lift crawling, kegel exercises, and pelvic tilt was prescribed for 2 times a day, 3 times a week during the duration of the study. Kordi et al. found that patients in the lumbopelvic belt group experienced the most improvement in pain at both 3- and 6-weeks follow-up. The exercise group still showed significant improvement in pain compared to the control group, although still less reported improvement than the belt group.[18]

Outside the realm of physical therapy treatment, a 2012 clinical study by Eggen et al. sought to evaluate the efficacy of group exercise in reducing both the prevalence and severity of low back pain and pelvic girdle pain in pregnancy. This observer-blinded randomized controlled trial enrolled 257 healthy pregnant women, assigning 129 to the training group and 128 to the control group. In the training group, women were prescribed group-based exercises once per week, and additional home exercises. Women were evaluated at baseline (gestation weeks 16-20), and at gestation weeks 24, 28, 32, and 36. The results from Eggen et al. indicated no significant difference in pelvic and low back pain between the exercise and control groups.[19] A more recent 2015 study by Haakstad et al. also sought to determine whether or not participation in a physical exercise program could prevent and treat pelvic girdle pain and low back pain. This study included 105 sedentary pregnant women and assigned them into either control or exercise groups. The women in the exercise group participated in a one-hour general fitness class twice a week for at least 12 weeks duration. Patients were assessed between gestation weeks 36-38 and again 6-8 weeks after delivery. Primary measurements included the number of women who reported experiencing pelvic girdle pain and low back pain, and secondary measurements encompassed severity of pain and limitations in daily activities and physical activities. The Haakstad et al. study found no statistically significant difference in pelvic pain and low back pain between the groups, concluding that participation in a physical exercise program did not appear to help prevent or treat PGP or low back pain.

Discussion

OMT as Treatment for Dysfunctional, Pelvic Girdle, and Low Back Pain

Osteopathic Manipulative treatment (OMT) has been shown by both Licciardone et al. and Hensel et al. to be effective modality to lessen the deterioration of back-related function.[14,15] Furthermore, in the Hensel et al. study OMT was found to help with pregnancy related pain.[15] However, one of the primary challenges in evaluating both studies remain the lack of statistical difference between the sham group and the treatment group. In Licciardone et al.'s analysis, there was a decrease in effect-size between OMT and usual obstetric care with sham ultrasound treatment than without.[14] Hensel et al. argued that this could be due to the placebo effect because they observed, with a larger sample size, that the OMT group was not significantly different from the usual care with sham ultrasound group.[15] The validity of these two studies were evaluated by a 2017 review from Franke et al. They determined 8 papers, including the Licciardone et al. and Hensel et al. studies, to be of low risk of bias, as they met at least 6 criteria of the Risk of Bias tool from the Cochrane Back Review group. These criteria consist of the presence of randomization, blinding, baseline comparability between groups, patient compliance, and drop out. The data from all 8 papers were collected to show that OMT had a medium-size effect on low back and pelvic girdle pain and increase functional status in pregnant women.[21]

Currently, there have been no studies that have compared sham treatment with OMT in treating and preventing pregnancy and postpartum pelvic girdle and low back pain. One of the current challenges in validating osteopathic manipulative treatment remains the relative lack of clinical studies evaluating OMT. This is not only limited to pelvic and low back pain, but also encompasses the spectrum of disorders OMT is utilized to treat.[22] However, interest in OMT research studies has been gaining traction. Recently published studies in OMT encompass a wide variety of pathologies, including the evaluation of OMT in the treatment of irritable bowel disease, endometriosis and chronic pelvic pain,

and in disorders of the cranial field and temporomandibular joint.[23, 24, 25] There is still much room for further evaluation of this topic. Future studies seeking to examine the effectiveness of utilizing OMT to treat pelvic and low back pain could benefit from studies outlining a specific sequence of OMT therapies to be used so that the study itself and consequent results could follow a more standardized criterion and could improve the reproducibility of study results.

Physical Therapy and Exercise as Treatments for Pelvic Girdle and Low Back Pain

While many of the studies purport improvement in PGP and LBP with both physical therapy exercises and physical exercise (including aerobic and strength training), other reviews have indicated that conclusive results are difficult to identity. A recent review by Almousa et al. sought to summarize the effectiveness of stabilizing exercises for pre- and postpartum women experiencing pelvic girdle pain. They identified only 6 studies with mixed results which fell within their inclusion criteria of pelvic girdle pain without back pain and those whose PGP did not have an identifiable musculoskeletal cause. They concluded that about half of the listed studies demonstrated some decrease in pain amongst women in the pre- and postpartum groups, but the other half of the studies were unable to indicate the effectiveness of pelvic stabilizing exercises in reducing pain.[26] In a similar vein, a review by Shiri et al. evaluated 11 randomized controlled trials to determine whether or not exercise is effective in the prevention of low back and pelvic girdle pain in pregnancy. They concluded that while exercise across these studies showed improvement in low back pain amongst pregnant women, the results were not conclusive for the effect of exercise on pelvic girdle pain in this patient population. The Shiri et al. review included any kind of exercise intervention and did not differentiate between physical therapy and exercise that can be categorized as aerobic and strength training.[27]

Several challenges to evaluating both the efficacy of physical therapy and exercise in the discussed studies include adherence to study protocol. In the Eggen et al. study, only 40% of the participants in the study performed their exercises as outlined in the study protocol. Well over half the participants failed to participate to completion of study.[19] The Haakstad et al. study experienced a similar problem in study participant compliance to the protocol.[20] Per the study, only 40% of the experimental group attended the exercise classes as indicated by the protocol. It is therefore challenging to draw definitive conclusions of a significant portion of the exercise group did not completely participate in the study as designed.[20] While this study does try to follow participants into the postpartum period in comparison to that of the Eggen study, the overall sample size is lower while still having low adherence to the exercise protocol in the experimental group. This highlights the challenges of encouraging patient participation in lifestyle modification as a treatment.

However, the ability to personalize treatment can be advantageous to patients while proving challenging in standardizing a study protocol to be most reproducible. Despite that, the focus specifically on exercises designed to stabilize the pelvis in comparison to the types of exercise and treatments prescribed in the control group strengthen the results of the Stuge et al. study.[16] Additionally, several of the physical therapy and exercise studies include relatively low numbers of study participants. The Stuge et al. study included only 81 women in their study, Kordi et al included 105 participants (about 30 per each arm), Haakstad et al. also included 105 participants.[16, 18, 20] The Eggen study included the largest number of participants at 257, with about 130 per each arm - far exceeding the total number of participants for the aforementioned studies.[19] Studies such as Kordi et al.'s study also did not distinguish between pelvic stabilizing therapy and aerobic exercises and other forms of training in their study, including both into a single treatment arm, while omitting both from the control arm. This can make identification of the palliative factors in the exercise arm more challenging, as these variables were grouped together instead of isolated.[18] Further evaluation of the efficacy and role of both physical therapy and exercise is required to better determine each modality's efficacy in the prevention and treatment of low back pain. The Kordi et al. study, however, did well at characterizing the types of exercises women in the exercise group were instructed to perform, indicating that this study was better standardized in its exercise group than other studies evaluated. However, the exercise group included both physical exercise in addition to the pelvic stabilizing exercises, which adds additional variability in assessing the outcomes of this group. Improvement, consequently, cannot be isolated to pelvic stabilizing exercise alone, as aerobic and stretching exercises were included in this group's regimen. Additionally, this study did not follow women for long-term pain improvement, only measuring at 3 and 6 weeks into the study. While this may limit the long-term impact of their results, Kordi et al. were able to feasibly indicate the efficacy both exercise and lumbopelvic belt usage in pelvic girdle pain improvement in the short-term.[18]

Conclusion

In conclusion, our literature analysis shows inconclusive benefit of using physical therapy and exercises to treat women with pelvic girdle pain and low back pain. On the other hand, adding osteopathic manipulative treatment to usual obstetric care shows a more promising result in reducing pain and improving back-function. The biggest challenges we faced in drawing a conclusion on these studies is the fact that their study designs all involved a lot of variability of treatments patients received as part of the experimental arms. These modalities rely on individualized assessment of patients to provide a unique treatment plan. Additionally, etiology of pelvic girdle and low back pain is often diverse, even if both fall under the realm of biomechanical dysfunction.[28] Though we found no adverse effects in using OMT, physical therapy, or exercises in the treatment of PGP and LBP, further studies are needed to effectively understand their utility in alleviating pelvic girdle and low back pain in both pregnant and postpartum women.

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A Review of Treatments to Replace or Reduce Opioid Consumption Postoperatively

Sravani Alla[+], B.S., Bridget Humphrey[+], B.S., and Brandon Nguyen[+], B.S.

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objectives*:* The purpose of this review is to introduce current research on opioid alternatives to reduce the prescription of opioid medications postoperatively.

Methods*:* A PubMed search was conducted on relevant research pertaining to the use of opioids and complementary alternative medicine in post-operative treatments. In this review, five studies from the years of 2005-2020 were identified and incorporated.

Results*:* Multimodal use of NSAIDs, acetaminophen, fascia iliaca compartment nerve block, and a ropivacaine nerve block after total knee arthroplasty require lower doses of opioid administration postoperatively. A preoperative ropivacaine nerve block used after knee, ankle, or shoulder arthroplasty resulted in patients requiring less opioid-based general anesthesia.

Conclusion*:* There is no singular evident analgesic substitute for opioids postoperatively. However, there are many interventions that can be implemented to decrease opioid consumption postoperatively.

Introduction

Currently, the abuse of opioids has become an epidemic within the United States. From the years of 1999 to 2017, nearly 400,000 people have died from opioid overdose.[1] The rise in these opioid related deaths can be characterized in three waves. The first wave, in the 1990s, was characterized by deaths from overdose of prescribed medications. It was found that anywhere between 21-29% of patients who are prescribed opioid pain medications for chronic pain abuse them.[2] Furthermore, 8% to 12% of patients will develop an opioid use disorder and 4% to 6% will transition from prescription opioids to heroin.[2] The over prescription of opioids by physicians has led to an epidemic that is causing a vicious addiction cycle.

The second wave, in 2010, was caused by an increase in heroin use. The third wave, beginning in 2013, was defined with deaths due to overdose of synthetic opioids, such as fentanyl.[1] Today, the high rates of opioid overdose related deaths make it extremely vital that interventions are found to reduce postoperative consumption of opioids.[3]

The vast amount of studies and literature regarding the opioid epidemic as well as the dangers of opioids has encouraged many patients to consider other forms of pain management, such as multimodal pain control and nerve blocks. The objective of this review is to highlight methodology to avoid as well as reduce opioid use postoperatively, to prevent opioid misuse, and subsequently decrease the number of opioid overdose related deaths.

Background

Multimodal pain control is a form of personalized medicine in which pain control is achieved through the use of many forms of pain relief simultaneously.[4] Though opioids are one form of multimodal pain control, there are a variety of other classes of drugs that can be used to target and treat postoperative pain such as NSAIDS, bupivacaine, regional anesthesia, and acetaminophen. Nerve blocks, especially peripheral nerve blocks, are gaining popularity in postoperative pain management as a form of analgesia. They are usually administered as a single injection or through continuous infusion through a perineural catheter.[5]

Methods

A PubMed search was conducted on relevant research pertaining to pain management in postoperative settings, with a specific focus on opioid use in comparison to alternative medications. Some phrases that were used for our search include: lower extremity, postoperative, opioid, analgesic, multimodal, pain, and reduced. Postoperative lower extremity studies that did not directly compare opioid usage between test groups were not included. As a result, there were no studies that involved alternative medicine like acupuncture, far infrared thermal rays, or peripheral nerve field stimulation. In this review, five studies from the years 2005-2020 were identified and included in this review. Studies that suggested the replacement of opioids with addictive non-opiate medications, such as ketamine, were excluded. It is counterintuitive to replace one addictive method with another. However, studies that discussed multimodal treatments in which opioids were used were included

since the multimodal approach has led to a reduced rate of opioid consumption.

Results

In a study of postoperative pain management in bunionectomy patients conducted by Daniels et al., the effect of diclofenac, an NSAID, was measured. In this study, 99 patients were given 25 mg of a soft gel capsule of diclofenac every four hours.[6] They were compared with 101 patients who had received a placebo. A soft gel capsule was used due to its quicker onset and higher, more rapid absorption.[6] It was found that the patients who used this NSAID had improved control of their pain postoperatively, without having to depend on opioid medication.[6] Furthermore, a study conducted by Remy et al., measured the effect of acetaminophen medication for postoperative pain management.[7] In this study, 265 patients were given morphine along with acetaminophen and 226 were given morphine alone.[7] Majority of these patients had undergone some form of orthopedic surgery, not solely limited to the lower extremity. However, these results can be extrapolated and applied to future lower extremity orthopedic surgeries. The medication was self-administered by the patients in both groups through a PCA pump.[7] The patients who were given acetaminophen used 20% less morphine than the patients who were given morphine alone.[7]

Jenstrup et al. conducted a double- blind randomized placebo-controlled trial evaluating the postoperative analgesic effects of a ropivacaine nerve block.[8] 75 participants were assessed after a total knee arthroplasty.[8] It is important to note that these patients were all over the age of 50.[8] There was a significant reduction in reported pain postoperatively only in knee flexion at 45 degrees ($P = 0.01$).[8] Participants were injected with a saline solution or the ropivacaine nerve block immediately after the operation.[8] The amount of morphine consumption during the first 24 hours postoperatively was significantly increased in the control group ($P = 0.006$).[8]

In a 2019 meta-analysis conducted by Gao et. al., seven randomized controlled trials were reviewed and analyzed to see how a fascia iliaca compartment block (FICB) can reduce pain and opioid consumption after a total hip arthroplasty.[9] 165 patients were placed in the FICB group and 160 patients were given placebos.[9] In this study, it was found that there was a significant decrease in postoperative pain score at the 12 hour ($P=0.02$) and 24 hour mark ($P=0.004$) in patients that received FICB when compared to the placebo group.[9] The difference in length of hospitalization was not stated to be significant.[9] The FICB treatment reduced the total amount of morphine consumed, and reduced the risk of opioid related negative effects.[9]

In 2017, Büttner et al. [10] implemented multimodal methods in a prospective randomized trial with postoperative arthroplasty patients. The addition of a ropivacaine nerve block immediately before receiving an opioid containing general anesthesia preoperatively in patients undergoing knee, ankle, or shoulder arthroplasty resulted in significant decrease in pain postoperatively.[10] In this study, it was found that in patients who had experienced pain within the first 24 hours postoperatively, 3% of nerve block participants reported pain while 80% of control participants reported pain.[10] Control participants spent significantly longer in the recovery room.[10] Furthermore, significantly more general anesthesia was required for the control group.[10] All of these results have p scores less than 0.001.[10]

Discussion

There are many precautions that can be taken when prescribing opioids for pain management in postoperative and preoperative settings.

Through non-opioid multimodal analgesia, like the use of NSAIDs and acetaminophen, the amount of opioids being consumed postoperatively by patients is dramatically reduced.[4] It was found that when NSAIDs were used in conjunction with morphine, there was an improved sense of pain control postoperatively and a lower dependendence on opioids, than when morphine was used alone.[4] Furthermore, opioid use postoperatively shows significant decrease in patient morbidity when prescribed with NSAIDs.[6] At the 48 hour mark postoperatively, patients who were given diclofenac potassium liquid-soft gels reported an average pain score of 3.29.[6] At the same time stamp, patients who received the placebo reported an average pain score of 5.74.[6] However, NSAIDs should be used cautiously in patients with gastrointestinal pathologies and renal insufficiency.[6] Acetaminophen has similar benefits to NSAIDs postoperatively. At 24 hours postoperatively, it was found that the addition of acetaminophen, along with morphine, in a PCA pump led to a 20% decrease in the amount of morphine being used. However, the addition of acetaminophen did not alleviate the adverse side effects of morphine, including sedation, vomiting, and nausea.[7] NSAIDs are most effective postoperatively when combined with opioids.[6] When NSAIDs are prescribed with opioids, patients report better control of postoperative pain and require lower amounts of opioid prescriptions to manage their

pain.[6] Implementing NSAIDs postoperatively will reduce opioid consumption.

In 2019, Gao et al. found that there was a significant reduction in opioid consumption and pain scores when the fascia iliaca compartment block was used following a total hip arthoplasty.[9] This shows that FICBs are extremely effective for postoperative pain management and should be considered to be a highly effective form of multimodal pain control.[9] Jenstrup et al. postoperatively utilized ropivacaine nerve block. After total knee arthroscopy, patients consumed less morphine and reported lower VAS pain scores.[8] Büttner et al. implemented ropivacaine nerve blocks preoperatively to participants undergoing arthroscopy on upper or lower limbs.[10] Patients reported significantly lower postoperative pain scores and required less opioid-based general anesthesia.[9] Jenstrup et al. and Büttner et al. provide methodologies that have the potential to reduce operative and postoperative opioid use.[8,10]

Conclusion

High rates of opioid related deaths make it imperative for physicians to limit opioid use in patient care. It is especially dangerous for patients to be prescribed opioids when they have a history of opioid misuse, as these patients are twice as likely to abuse opioids postoperatively. [3,11] Decreasing opioid consumption is a measure that physicians should be taking to decrease opioid dependence and overdose. Multimodal analgesics and nerve blocks decrease opioid consumption postoperatively.[6-10] These studies were conducted after different types of surgeries. Therefore, the level of pain management may differ across these surgeries. These methods may not provide enough analgesic effects on their own. It is important for more research to be done to evaluate how these or other methods can replace opioids in postoperative care.

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Off-Label Use of Low Dose Naltrexone in the Treatment of Chronic and Neuropathic Pain: A Review of Current and Potential Applications

Vivek Kommineni[+], B.A., Shivam Patel[+], B.S., and Imran Peer[+], B.S.

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objective: Naltrexone is an opioid antagonist currently approved for the treatment of alcohol withdrawal symptoms at standard therapeutic dosages. However, the drug can function as an antagonist of non-opioid immune cell receptors at low doses, inhibiting certain aspects of the inflammatory response cascade. The objective of this study is to evaluate the potential use of low dose naltrexone in the management of chronic and neuropathic pain.

Methods: A search of the PubMed database was conducted using combinations of the search terms "low-dose naltrexone," "chronic pain," and "neuropathy." Studies were selected from the primary search and from references cited in these studies.

Results: Administration of low dose naltrexone has been shown to provide a significant decrease in pain suffered by patients with complex regional pain syndrome, multiple sclerosis, and fibromyalgia in several studies. Serum inflammatory markers are shown to be increased in painful diabetic neuropathy and the antagonistic effects low dose naltrexone exerts on toll-like receptor 4 and the opioid growth factor receptor.

Conclusion: Low dose naltrexone therapy has shown promise in the management of chronic pain by reducing pain levels, pain sensitivity, and the transmission of pain signals to the brain. Further research at a larger scale to determine viable dosing strategies, side effect profiles, and efficacy would be beneficial.

Introduction

Chronic pain is a complex condition with a multifocal etiology; it can be idiopathic, associated with trauma, accompanying medical conditions, and even iatrogenic. Multiple factors, ranging from genetics to emotional and mental well-being, can modulate the experience of pain for patients. An objective finding is not always associated with the presentation of pain.[1] These factors can serve as a significant source of frustration for clinicians and the availability of a wider array of treatment options would help relieve these issues.

Neuropathic pain, a common manifestation of pathologic disorders involving the nervous system, is just one subset of chronic pain. Diabetic peripheral neuropathy is commonly encountered as a cause of refractory neuropathic pain in the podiatric setting. In conditions such as this, low dose naltrexone (LDN) is a novel therapy that has the potential to serve as a powerful tool in providing symptomatic relief.

Opioids have long been the standard of care for treating chronic pain, mainly due to the limited availability of viable therapeutic options.[2] Freehanded prescribing practices combined with the addictive properties of the medications themselves have led to the opioid crisis we face today.

Naltrexone, an opioid antagonist, has been found to have paradoxical analgesic effects at low doses. Multiple studies have evaluated the potential analgesic effects of LDN with the first human clinical trial published in 2007.[3] Most of the research conducted on LDN has examined its impact on pain associated with rheumatologic conditions. However, successful treatment of painful, refractory diabetic peripheral neuropathy in the lower extremity has also been reported in the literature.[4] The objective of this article is to provide a review of the pharmacological properties of naltrexone at low doses, review the applications that have been explored, and discuss the potential application to the setting of chronic and neuropathic pain.

Background

Naltrexone is an opioid antagonist available in oral or injectable depot formulations.[5] The depot formulation is approved by the Food and Drug Administration (FDA) for long term use in alcohol dependence.[6] The oral formulation is compounded as naltrexone hydrochloride and indicated for use in alcohol dependence and the blockade of exogenously administered opioids.[7] The mechanism and chemical structure are conserved; naltrexone is a congener of a naloxone derivative that functions as a competitive antagonist of the μ, κ, and δ opioid receptors in the central nervous system. The drug antagonizes the opioid effects of respiratory depression, euphoria, and drug craving. The active metabolite of the drug, 6-β-naltrexol, also functions as an opioid antagonist.[8]

It is hypothesized that naltrexone has another mechanism of action at low doses. While

standard doses antagonize the opioid receptors, the drug interacts with non-opioid receptors at low doses, most notably toll-like receptor 4 (TLR-4). TLR-4 is a receptor expressed by macrophages, with the most notable effect occurring in microglial cells.[8] It is reported that activation of microglia is associated with the production of proinflammatory cytokines and reactive oxygen species which ultimately leads to the symptom of neuropathic pain and other symptoms of chronic conditions.[9] It is theorized that competitive inhibition of TLR-4 creates the analgesic effect of LDN. However, this inhibitory effect is limited in the setting of TLR-4 activation by external stimuli. The inflammatory response is found to be intact after activation by exogenous sources. Lipopolysaccharides (LPS) from gram-negative bacteria can stimulate the immune response, activate macrophages and their derivatives even in the presence of LDN.[8,9]

The antagonistic properties of naltrexone at TLR-4 leading to suppression of pain sensitivity have shown promise in the management of conditions chronic regional pain syndrome (CRPS), multiple sclerosis (MS), and fibromyalgia. It has been suggested that the immunomodulatory pathway of LDN allows it to function as an anti-inflammatory agent in the CNS. This function, combined with the systemic anti-inflammatory effects, has been shown to lead to a reduction in markers associated with fibromyalgia.

LDN has also been proposed as an antagonist of the opioid growth factor receptor (OGFr). The OGFr is a regulator of DNA synthesis and cellular proliferation and it is currently hypothesized that changes in opioid growth factor (OGF) binding OGFr consequently contributes to neoplasm pathogenesis.[8,10] Naltrexone competitively inhibits the OGFr, subsequently leading to increased cellular proliferation. LDN is administered at less than 10% of the standard naltrexone dose of 50 mg and the drug has an active half-life of 4 hours. As such, the active concentration of the drug falls out of the therapeutic index before the next dose is administered. This results in an intermediate blockade of the OGF-OGFr axis, leading to an upregulation of the production of OGF and OGFr and increasing the sensitivity of OGFr.[8,10]

There are no current indications or guidelines for the use of LDN approved by the FDA. In research trials, the medication has been titrated to a maximum dosage of 4.5 mg. Doses above this level have been demonstrated to lose therapeutic efficacy. Patients are typically started at a dose of 1.5 mg before being transitioned to 3 mg and finally to a dose of 4.5 mg.[8]

Methods

A search of the PubMed database was conducted using combinations of the search terms "low-dose naltrexone," "chronic pain," and "neuropathy." Studies were selected from the primary search and from references cited in these studies. Studies applying to chronic and neuropathic pain were included, while studies involving animals were excluded from the review.

Results

In a 2017 study, Parkitney and Younger conducted a single-blind trial of LDN in eight women diagnosed with fibromyalgia for an average of 14 years. They found statistically significant decreases in serum levels of pro-inflammatory cytokines promoting allodynia, hyperalgesia, and nociception after an 8-week course of oral LDN.[11] In addition, the study found patients had a 15% reduction in fibromyalgia-associated pain and an 18% reduction in overall symptoms after completing the eight-week course. Several similar studies have also shown a reduction in fatigue and an improvement in functionality in fibromyalgia patients following the administration of LDN.[12,13,14]

In a 2015 retrospective study of 215 patients with multiple sclerosis, Turel et al. reported similar findings.[15] In the study, patients were placed on an LDN regimen of 3.5 mg daily and were assessed after seven years. 59% of patients reported a decrease in fatigue and 75% reported a stabilized or improved quality of life. The study was well tolerated as only 2% of patients reported increased fatigue while 4% reported a worsened quality of life with the drug. The study also found that 77% of participants reported no side effects over the seven-year course. Sleep-related side-effects were noted by 11% of participants, 5% reported excessive dreams, and 6% reported insomnia.[15]

The use of LDN therapy for symptomatic relief in patients suffering from painful diabetic peripheral neuropathy has also been proposed as a novel treatment. Previous studies have demonstrated that there are increased serum levels of IL-6, IL-1, and TNF-α in patients suffering from painful diabetic neuropathy.[16] A 2016 case report by Hota et al. found success in using a regimen of LDN to alleviate the symptoms of painful peripheral neuropathy in accordance with this mechanism. The patient reported had previously experienced no symptomatic relief with amitriptyline, pregabalin, duloxetine, lamotrigine, and various non-steroidal anti-inflammatory drugs. LDN was administered in sequential two-week courses of 1 mg, 2 mg, and 4 mg. The patient initially reported a pain score of 90% on the visual analogue scale and reported a score of

5% after completing six weeks of therapy. The patient continued to take a 4mg dose of LDN for the next two years and did not report any recurrence in symptoms.

Discussion

The studies evaluated in this review have shown significant success in the treatment of chronic and neuropathic pain. Further studies are indicated as the treatment potential of the drug extends beyond the studies completed to date. Current reports on LDN are limited in number and lacking in patient volume. Larger future studies exploring the efficacy could be extremely beneficial in evaluating the potential outlined by existing case reports**.**

The impact of neuropathic pain in cancer patients is a potential future avenue for LDN treatment. A 2012 meta-analysis of over 10,000 patients by Bennett et al. found a 39% incidence of neuropathic pain in cancer patients.[17] A 2013 study by Fallon found a 90% incidence of neuropathic pain in cancer patients receiving neurotoxic chemotherapy.[18] The inhibitory effect LDN exerts on cell cycle dysregulation serves as a potential intervention. The antagonistic properties of LDN on the OGFr are potentially of value in the management of cancer and subsequent neuropathic pain.[10]

LDN has favorable advantages in cost and side effect profile. The oral formulation is not patented and is relatively inexpensive on the market. LDN does not currently share the same advantages as it is not approved by the FDA. As such, it is difficult to obtain outside of clinical trials at this time. However, the cost is not expected to be significantly different upon approval as only the medication compounding will change.[8]

Few reported adverse side effects have been noted with LDN with one study even showing that LDN was better tolerated than the placebo administered. This is a major advantage when considering the side effect profile of NSAIDs and opioids. Opioids and LDN are found to have a similar side effect profile on the central nervous system. They share the common side effects of insomnia, vivid dreams, and headaches. However, naltrexone does not share the more severe side effects of respiratory depression and physical dependence. The side effects reported with LDN have not been found to be life threatening and most can be ameliorated with simple interventions.[8]

Insomnia can be managed by administering the medication in the morning and reducing the dose from 4.5 mg to 3 mg. It has been found that the quality of sleep is not affected in patients reporting vivid dreams and the frequency of the dreams has been shown to diminish with time. Headaches have also been reported as a side effect although a study examining the safety and efficacy of LDN found the group was comparable to the control group.[8]

While the long-term safety for large doses of naltrexone is known, little is known about the drug with chronic low dose use. In addition, not enough research has been conducted to find the optimal dosage for treating specific conditions. Further research is needed to evaluate efficacy, dosing, and long-term safety profiles of the medication. These studies could also be beneficial in establishing an FDA-approved indication for the use of the medication. This would increase access to the therapy as not all insurance companies cover off-label uses of medication.

Conclusion

The use of naltrexone in the management and treatment of chronic pain and certain inflammatory conditions is supported by its pharmacologic properties. Current trials exploring off-label use of naltrexone have shown promising results. The limited availability of options capable of treating and managing chronic pain conditions combined with patients reporting relief on LDN therapy suggests more potential applications of its use should be explored. However, studies need to be conducted on a larger scale to determine optimal dosing for specific conditions and safety profiles for the long term from usage of LDN.

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Association of Fat-Mass with Non-Specific Foot Pain in Obese Adults

Faustine Vuong[+], B.S., Tal Boussi[+], B.S., and Katherine Gutierrez[+], B.S.

[+]Western University of Health Sciences, College of Podiatric Medicine

ABSTRACT

Objectives: The goal of this review is to interpret the association of fat mass with non-specific foot pain in obese adults.

Methods: A review was done using the engines: PubMed, Google Scholar, and Wiley Online Library. The search terms included "foot pain," "obesity," and "fat mass." In total, five articles were selected that focused on obesity related foot pain.

Results: Fat Mass Index was utilized by these studies and is defined as a measure of relative fat content, independent of the fat-free mass. An analysis of the literature showed an overall common use of the Manchester Foot Pain and Disability questionnaire to test for the pain experience.

Conclusion: The positive association between fat mass and foot pain in obese adults was unanimously agreed upon by the various literature. However, the inflammatory physiological cause of foot pain is still uncertain and must be delineated further in future studies.

Introduction

According to the World Health Organization, worldwide obesity affects 13% of adults.[1] Based on a U.S. study of obesity trends among adults, the prevalence of obesity in adults was 39.6% between 2015-2016, with an increase in prevalence in adults over the age of 40.[2] Foot pain has been shown to be significantly associated with higher body weight and higher body mass index (BMI) which can lead to mechanical pathologies of the lower limb.[3,4]

In a 2017 study by Walsh et al. on the relationship between change in body weight and foot pain over two years, participants who saw an increase in weight also experienced an increase in plantar pressure and foot pain.[5] In 2015, Butterworth et al. found that body weight was a significant contributor to foot pain, even after controlling for foot structure in obese adults suffering from general foot pain.[6] The mechanism through which obesity leads to foot pain is not fully understood. A possible mechanism proposed in a 2016 article by Walsh et al. suggests that low-grade inflammation produced by excessive adipose tissue or other metabolic processes involving inflammatory responses causes foot pain.[7] Both of these studies utilized fat mass composition as assessed by the Fat Mass Index (FMI), characterized as a measure of relative fat content, independent of the fat-free mass present unlike the percentage of body fat. Most of the studies assessed in this review utilized the Manchester Foot Pain and Disability (MFPDI) questionnaire to evaluate the pain experienced by the participants.

It is recorded that 24% of adults above the age of 45 have chronic foot pain.[8] Furthermore, past literature has stated that obesity is a strong risk factor for foot pain.[8] Therefore, the aim of this review was to understand the association of fat mass with non-specific foot pain in obese adults.

Methods

A review of published literature within the last 10 years regarding fat mass was performed using the search engines PubMed, Google Scholar, and Wiley Online Library. The key words implemented for the search included "foot pain," "obesity," and "fat mass." Articles that included pediatric demographics were excluded as well as articles that did not specify fat mass as an independent variable in foot pain. Furthermore, articles that focused on multiple body systems were also excluded. In total, five published articles met the criteria outlined.

Results

To support the relationship between BMI or fat mass as a predictor of foot pain, in 2013 Butterworth et al. conducted a 3-year longitudinal study and found that total fat mass correlated with foot pain with a statistically significant value of $p=0.01$. FMI was also found to be a positive predictor of foot pain with a significance value of $p=0.02$.[9] BMI was not seen to be a predictor in foot pain and had a significance value of $p=0.07$. However, there was a tendency towards those with incident pain to have a higher BMI with a significance value of $p=0.12$.[9] It was noted that participants that had foot pain at follow-up had a higher baseline BMI and fat mass.

Similarly, looking at the association between fat mass and fat-free mass, a 2012 study by Tanamas

et al. assessed BMI, total fat mass, total muscle mass, FMI, and other factors using logistics regression analysis to assess the relation between fat distribution and foot pain.[10] Taking into consideration fat-free mass, there was no difference found between the foot pain group and the control group in this regard. However, the study found a strong relationship between fat mass and foot pain with an odds ratio of 1.05, and within 95% confidence interval between 1.02–1.09 and fat mass index odds ratio of 1.16, and 95% confidence interval between 1.06–1.28, with an increase in android/gynoid fat in those with foot pain.[10]

Further investigations assessed other mediating factors contributing to the impact of FMI in foot pain. One such study in 2016, Butterworth et al. conducted an all-male 5-year longitudinal study on foot pain as related to fat mass.[8] The results were based on MFPDI questionnaire responses and dual X-ray absorptiometry to assess fat mass. There was a statistically significant correlation between fat mass and foot pain using multivariate analysis with a significance value of p=0.03 and p=0.04 when adjusted for age, depression, mobility, education, and other confounds.[8] Interestingly, in participants younger than 50 years of age, no association between body composition and fat-free mass was observed.

In 2017, Walsh et al. conducted an all-female investigation of the contribution of BMI, visceral/subcutaneous ratio, android fat mass, gynoid fat mass, total body fat mass, total fat-free mass, and android/gynoid fat ratio was carried out in a sample of 40-65-year-old participants for a period of 3 months.[11] The pain was assessed using the MFPDI, while body composition was measured by dual X-ray absorptiometry. Though no significant difference in body composition was found between the foot pain and control group, the severity of onset disabling foot pain was closely linked to visceral/subcutaneous ratio and fat mass.[10]

Investigating the relationship between inflammatory processes and the mediation between fat mass and foot pain, a 2016 study by Walsh et al. quantitatively assessed for the presence of serum adipokines associated with FMI in prevalent foot pain.[7] The results of this study evaluated for the presence of tumor necrosis factor (TNF) and interleukin-6 (IL-6) inflammatory cytokines. The presence of cytokines was found to be not statistically significant, however for every unit increase of FMI, prevalent and future pain increased by 8% and 6% respectively.[7]

Discussion

The results were consistent with the findings of past resources presenting that foot pain is positively associated with fat mass.[10] This review explains the findings of the 2016 Butterworth et al. through the metabolic pathway of pain and inflammation. Adipose tissue has metabolic control over endocrine organs that produce: leptin, estrogen, resistin, tumor necrosis factor-α (TNF-α), and interleukin-6.[8] These proinflammatory cytokines control and act as key factors in the development of pain. Although the results showed that IL-6 and TNF-α levels were not found to be significantly associated with pain[7], the 2016 article by Butterworth et al. suggest further indication that inflammation has a significant influence on foot pain in adults.[8]

Throughout the studies analyzed there were notable limitations in the age range of participants, with age averages ranging in the mid-40s to 50s. In addition, a reoccurring limitation present throughout each of the studies included the restriction among the sexes represented with a smaller proportion of men in relation to women,[9,10,11] which the 2016 Butterworth et al. study attempted to address in their all-male study.[8]

The studies contained factors that potentially confounded effects on pain, including socioeconomic status, age, and population sampling. Methodological changes can be made to increase the construct validity of these studies. It was expressed in 2016 by Butterworth et al. that the cross-sectional study design does not properly exhibit the change of foot pain over time.[8]

A consensus on the directionality of the relationship between physical activity and foot pain is still yet to be fully understood. It is not clear whether a lack of physical activity leads to foot pain, or foot pain limits the ability to be physically active. Perhaps it is more nuanced than directionality, as characterized by the work done with inflammatory cytokines by the 2016 Walsh et al. study.[7] It is relevant for future studies to explore the mediation through the metabolic and biological factors related to an increase in fat mass in adult patients. Due to the interplay between factors and pathology, it is important to realize the need for a holistic approach within the clinic setting.

Conclusion

The literature overall indicates that fat mass is a primary indicator of foot pain. Limitations were noted in each of the investigations, each pointing to the need for further research in the role of fat mass as a causative factor for non-specific foot pain. Metabolic mechanisms associated with fat mass including adipokine contribution to foot pain remain yet to be validated and explored. Similarly, further investigation is needed on the implications of fat mass in biomechanical and metabolic mechanisms

within the tissues of the foot. It is important for physicians to be able to explain and reframe a patient's perspective on their dietary lifestyle and how body composition can affect their quality of life. Further research on the treatment of foot pain by fat mass reduction is a topic that has begun to emerge. Studies such as the 2018 Walsh et al. focused on the reduction of foot pain on patients who underwent bariatric surgery, resulting in a reduction of fat mass composition[12] need to be further explored. In conclusion, the literature agrees that high levels of fat mass in obese adults are positively associated with foot pain. Further research is needed to understand the pathophysiology behind the association of fat mass and foot pain in obese adults.

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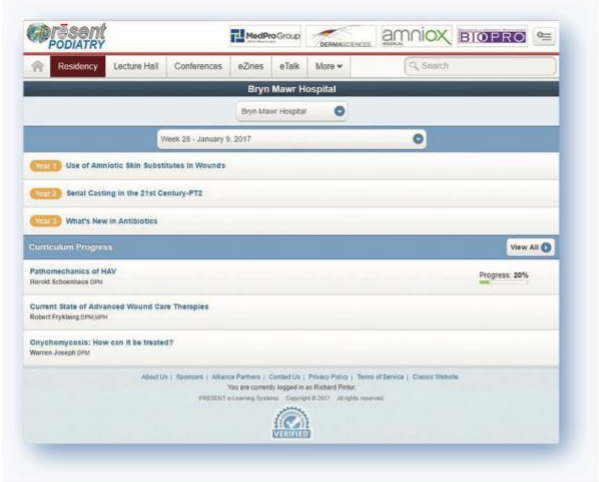

Attend these conferences for the most up-to-date residency education available

Podiatrists in training, Fellows, Residents and Students, NEVER pay a registration fee and are always invited to attend our conferences for FREE

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Teaneck Marriott, Teaneck, NJ
August 14-16, 2020

MIDWEST 2020

Residency Education Summit Midwest
Hilton Chicago / Oak Brook Hills, IL
September 25-27, 2020

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2430 K Street, Suite 200 • Sacramento, CA 95816
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