

The Female Athlete Triad and It's Long-Term Effect on High School Female Athletes

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Abstract

With the passage of Title IX in 1972, females have come a long way in regards to sport participation. This was something that was considered great for women and has led to the tremendous increase in female participation in sports in high schools. While participation in sports has many benefits, one unforeseen consequence was the emergence of the female athlete triad. The female athlete triad is composed of three things, low-energy availability (disordered eating), menstrual irregularities, and negative effects on bone mineral density. The purpose of this synthesis was to review the literature on the female athlete triad and its long-term effect on high school female athletes.

Chapter 1 – Introduction

Before the passage of Title IX, women didn't have too many opportunities to participate in the number of sports that they do today. Thein-Nissenbaum (2013) discussed that since the passage of it, there has been a tremendous leap in sports and athletics for females, and just physical activity in general. With an increase in physical activity can come many positive benefits which may include an increase in ones' self-esteem, body-image, and a woman's overall health.

Being physically active is important for one's overall health, whether female or male. However, there are some sports out there that really focus on and emphasize the aesthetics of ones' body. So even though this happens with both male and female sports, a man's body can't physically go through what a female's body may experience when it comes to menstrual irregularities. This may be the big difference when looking at males and females. Thein-Nissenbaum, Rauh, Carr, Loud & McGuine (2012) mentioned that there has been a difference in injury rate between males and females within the same sport. They added to this mentioning how menstrual irregularities can negatively affect a female's bone mineral density.

The female athlete triad is a topic that many people may not have even heard about before. For some athletes, this subject may not be something that they will learn about until they take a college course, and that is only if it pertains to their major. What exactly is the female athlete triad then?

The female athlete triad is a component of three things for females which include; 1) low energy available (disordered eating), 2) menstrual irregularity (MI), and 3) bone

mineral density (Brown, Wengreen, Beals, & Heath, 2016, Thein-Nissenbaum, 2013, Thein-Nissenbaum, et al 2012,).

With each article that is discussed in this synthesis, all of the authors discuss the different aspects of the triad. The first of the three components of that triad that will be addressed is energy availability, or disordered eating. This has to deal with the amount of food an athlete takes in with how much energy they are expending each day. Melin, Tornberg, Skouby, Moller, Faber, Sundgot-Borgen, & Sjodin (2016) mentioned that this included an athlete's exercise expenditure as well.

The second component will be menstrual irregularities. This could include when a female may experience her first menses and then it ceases for a period of time, or even the delay of ones' first menses. Lastly, the third component of the female athlete triad is bone mineral density. This has to deal with osteoporosis, or the strength of a females growing bones. Laframboise, Borody, & Stern (2013) discussed how osteoporosis is a skeletal disorder where ones' bone strength is compromised leading to an increased risk of a fracture.

Statement of the Problem

Females are given a lot more opportunities to participate in sports and athletics- the world has come a long way since the passage of Title IX. When it comes to females participating in sports and athletics, there are just more things that we need to be aware of, like the female athlete triad. Not all females will succumb to components of the triad, but there will be some who do.

Cruz-Sáez, Pascual, Salaberria, Etxebarria, & Echeburúa (2015) mentioned that there are adolescents out there who do partake in eating and weight control habits that

aren't healthy for their environment. Some of these unhealthy habits may include restricting the amount of food they intake, increasing their workout program, taking dietary supplements, and even having bulimia tendencies. With all of the research that is out there, many researchers have found that there is a link between energy availability, menstrual irregularities, and bone mineral density, and these three components can have an effect on a female athletes' body and playing time.

The emphasis that the media may place on appearance doesn't help either-but can this place harm on ones' body? For females, it can mean a lot. Rauh, Nichols, & Barrack (2010) discussed the negatives effects that females may experience with a sporting-related injury. They talked about how it may reduce their season playing time, and depending on the severity of the injury, and can lead to one being out for the entire season.

Purpose of the Study

The purpose of this synthesis is to review the literature on the female athlete triad and its long-term effect on high school female athletes.

Operational Definitions

1. Female athlete triad- The link of disordered eating, menstrual irregularities (or dysfunction), and bone density loss that have been found to occur in female athletes (Roberts, Glen, & Kreipe, 2003).
2. Menstrual Irregularity-abnormal menstrual function (Thein-Nissenbaum, et al, 2012).

3. Energy availability- The amount of energy that your body needs for the usage of sport performance and training (Laframboise, Borody, & Stern, 2013).
4. Bone mineral density-used for diagnosis regarding the quantity of mineral in ones' bone, which is a component of bone strength.
5. Osteoporosis- When your bone strength is compromised that can allow a person to be at an increased risk of fracture. This is a skeletal disorder (Laframboise, Borody, & Stern, 2013).

Research Questions

The following research questions in this study will be:

- 1) What are the effects of the female athlete triad on an athlete's sport injury and participation?
- 2) What are the long-term health effects of the athlete?
- 3) What steps can be used to educate female athletes on the female athlete triad as a method for prevention?

Delimitations

1. Participants in the review of literature were females in 7-12th grade, or 13-18 years of age.
2. Participants who have experienced a menstrual cycle at a younger age (13-14), or could be 15 years of age if they have not.
3. Participants included in the review of literature were female athletes.
4. Articles used in this research synthesis were full articles that were in peer and published journals between 2010-2020.
5. All subjects participated in interscholastic sports.

Chapter 2 – Methods

The purpose of this chapter is to review the methods used to review the literature on the female athlete triad and its long-term effect on high school female athletes. The studies collected for this synthesis were located using the EBSCO database from The College at Brockport's Drake Library. Within the EBSCO database the following databases were searched: SPORTDiscus, Sport Medicine and Education, and Academic Search Complete.

Within these databases, there were a total number of 40 articles that met the criteria for inclusion that were considered as part of the critical mass within this literature review. In order for an article to meet the criteria for selection in this synthesis it must have been published between 2010-present, this will provide this synthesis with the most up to date and current information available. Other criteria for selection included scholarly and peer reviewed articles that were full-text. Having scholarly and peer reviewed articles provides more validity within the articles and better overall quality. Other articles or sources selected as part of this literature review provided context about the topic, background information and supplemental information to complete the review. All articles and sources are appropriately cited in the reference section of this paper.

In order to gather valuable articles for this synthesis certain keywords and phrases were used when searching the data-base. The first keyword searched was through SPORTDiscus, using the words female athlete triad and high school that resulted in 45 number of hits. With searches through other databases, there were similar results-

Academic Search (40) and Sport Medicine and Education (20). These key words were chosen because the female athlete triad is the main component that directly relates to the main topic at hand. The words high school were searched because the data that will be looked at will involve high school female athletes who may experience components of the female athlete triad.

After this, another further search using those same key words to search, but adding in injuries were done on SPORTDiscus, which yielded 20 results, Academic Search-10 results, and Sport Medicine and Education-20 results. Injury was added to see if there were more articles which focused in on high school female athletes and their encounter with injuries and the female athlete triad.

Articles that were selected for use in this synthesis were scholarly and peer reviewed articles that were full-text. Also, when selecting articles for use in this synthesis it was important that each article selected had valuable information related to the female athlete triad and high school female athletes.

Specific criteria were used in order to be a part of the literature review. All of the articles selected were based on the female athlete triad. Participants in the studies reviewed were high school female athletes participating in one or more interscholastic sports. Participants were also in the secondary grade level ranging from 7th to 12th grade.

For this synthesis a total number of 10 articles were used to compile data on the topic of the female athlete triad. Articles came from a variety of journals including *Journal of Health Psychology*, *Journal of the Canadian Chiropractic Association*, *International Journal of Sport Nutrition & Exercise Metabolism*, *International Journal of Sports Physical Therapy*, *Journal of Athletic Training (National Athletic Trainers'*

Association), Clinical Pediatrics, Adolescence, Sports Health, and Journal of Pure Power.

The critical mass for this synthesis is comprised of 1,267 number of participants. Within the 10 number of articles used for the literature review there was a total of 1,267 high school female athletes that were participants in the all of the research that was conducted. The grade level for participants were between 7th to 12th grade. Some researchers required participants to have experienced menarche to be a subject, and if they have not reached that point then they were required to be at least 15 years of age.

Data were analyzed using the following methodologies for the studies under review. The majority of these studies included a variety of surveys and questionnaires. A number of these studies also used the EDE-Q questionnaire when it came to gathering information on eating behaviors. Other studies had collected information on body composition utilizing a dual energy x-ray scanner which allowed researchers to gather information on the participants bone density in major areas like the spine, femurs, and other major areas, body composition, and body fat percentage as well. Some information that was gathered in relation to athletes and their injuries included reports from coaches and trainers, and in some, it came from the athletes themselves through interviews and food journals as well. Between the recommendations from the authors data that was presented in the critical mass, a discussion of the female athlete triad and its relation to injuries were then formed.

Chapter 3 – Review of Literature

The purpose of this chapter is to present a review of literature on the female athlete triad and its long-term effect on high school female athletes. In particular, the following topics will be reviewed: energy availability, menstrual irregularities, and bone mineral density. These are the three components to the Female Athlete Triad. This review will look at them and how they are related to injury and even look preventative aspects for the triad.

When you think about athletes, one would think that they need to acquire and maintain a certain amount of energy when it comes to the nutrients that they put into their body to allow them to perform at their best. What many female athletes don't know are the component of the triad, and how it can affect their time in their particular sport or sports. The first component of the triad discussed in this review will be the amount of food an athlete consumes in relation to the amount of energy they expend, or energy availability.

Energy Availability

What is energy availability? Melin, et al (2016), put this term easy for their readers to understand in their research. It is the amount of energy athlete's need in relation to the food they consume and their exercise expenditure. In relation to their study, that included 25 high school female athletes and in relation to energy availability, they recorded what their participants consumed for 7 consecutive days. They also logged their training and exercise for those days, and calculated their energy availability by using their energy intake and exercise expenditure throughout those 7 days.

From their results, they found that the participants with a lower energy availability displayed a higher training volume than participants who has a higher energy availability. They ultimately found that energy availability was positively associated with the amount of energy, or food, that participants consumed. The reason for a lower energy availability could be due to the intentional restriction of the food the athletes consumed to try and maintain a lower body weight, or from eating disorders.

In other findings, Rauh, Nichols, & Barrack (2010) research study consisted of 163 interscholastic female athletes. Their research on eating attitudes and behaviors by mentioning that they had their participants complete an Eating Disorder Examination Questionnaire (EDE-Q) survey designed for athletes to self-report on their eating behaviors. They also would report any concerns they may have had on their weight, shape, etc. The athletes completed the surveys near the beginning of the season to determine their eating attitudes and behaviors.

In relation to energy availability, they found that athletes who did restrict their diet, or showed symptoms or disordered eating, were 7 times more likely to report a musculoskeletal injury than athletes who had normal eating behaviors. This ultimately showed that athletes who did have unhealthy eating behaviors were more prone to developing some sort of musculoskeletal injury.

Similarly, in another study done by these same researchers, Rauh, Barrack, & Nichols (2014) discussed their research in relation of female runners and its relatedness to the female athlete triad. This particular study consisted of 89 interscholastic female athletes participating in cross-country and were monitored throughout their sport season. When it came to energy availability, or disordered eating, they collected data on eating

habits from the EDE-Q which assessed disordered eating attitudes/behaviors. They collected daily injury reports from athletes throughout the study as well.

From their study and the injuries that were reported, they found that disordered eating was found higher in the female runners who were a part of their research. They had a higher number of athletes with disordered eating, or who were concerned with their weight, shape, and eating habits who also encountered lower extremity musculoskeletal injuries. Based on the data from their surveys though, they reported that they felt athletes weren't being truthful in their eating behaviors on the survey.

In addition to this, Thein-Nissenbaum, et al (2012) discussed that this relates to ones' dietary intake minus ones' energy expenditure. With anyone, including athletes, this can be affected by disordered eating patterns, which may include anorexia and bulimia. Thein-Nissenbaum, et al (2012) had a lot more to say when it came to menstrual irregularities and injuries.

Menstrual Irregularities

Thein-Nissenbaum, et al (2012) also discussed menstrual irregularities and its relationship to musculoskeletal injuries in high school female athletes. In that study, researchers were trying to determine how prevalent the relationship was between menstrual irregularities and injury among high school athletes. Here they designed a cross-sectional study where they included 249 participants from 3 different high schools that participated in athletics. Throughout their sporting season, athletes completed surveys that discussed any injuries that they may have incurred, the number of days that they may have missed due to their injury, and their menstrual history within the past year of the study.

Overall, they found that the relationship between those athletes who had reported menstrual irregularities and also reported injuries were high-those athletes who had reported menstrual irregularities had experienced more injuries than those who had reported a normal menstrual cycle.

Similarly, Rauh, et al (2014) had looked at injury and menstrual history as well, but in their one research, they also kept in account energy availability as well. In that study, they were trying to determine if there was an association between the triad and the risk of lower extremity musculoskeletal injuries. Within this study, they collected data daily on injury reported. They also had participants complete an EDE-Q questionnaire in relation to their eating attitudes/behaviors and on their menstrual history as well. They got even more in depth by measure participants bone mineral density as well.

In this research, they really looked at how menstrual irregularities can lead to injury. From their study of 89 female athletes, they found that almost 43% had experienced at least one lower extremity injury. Yes, they took into consideration energy availability, but they also looked at the athlete's menstrual history as well.

From this, they found that there was a relationship between oligo/amenorrhea. These researches felt that close monitoring of adolescent female runners, during and off of season, could be critical in reducing the risk of injury for these athletes.

Just like in their later study as well, Rauh, et al (2010) was trying to determine if there was a relation between the triad components. Here they had their 163 participants complete questionnaires and surveys as well. When it came to their findings in relation to menstrual irregularities, they found that having a history of menstrual disruptions is indeed a risk factor for injuries.

Additionally, Thein-Nissenbaum, et al (2013), didn't find similar prevalence's on their findings with menstrual irregularity. Their research was more focused in on aspects of the triad in relation with athletes who have taken oral contraceptives, and they found that, in their study of 291 participants, 14% of OCP users had experienced menstrual irregularities whereas 19.4% of non-OCP users reported irregularities. Although these numbers separately are less than the previous researchers' findings, combined they are pretty comparable.

These researchers go on to mention the importance of a female menstruating and its positive influence that it has on a female's bone development. When adolescents are developing, its crucial for females to have those higher estrogen levels that they experience during menstruation, accruing the bone mass during this age can lead to a lifetime benefit for them when it comes to their bone mineral density.

Bone Mineral Density

Now why does bone mineral density come into play with the female athlete triad? Here is where we really look at it in relation to musculoskeletal injuries. If an athlete experiences a musculoskeletal injury, it can really affect the amount of time she spends participating in her sport. So how can it affect athletes?

In a study done by Thralls, Nichols, Barrack, Kern, & Rauh (2016), they looked at body mass-related predictors among female athletes when it came to the female athlete triad utilizing the ideal body weight (IBW), or Hamwi formula. Results from the Hamwi with less than 80% and 90% were classified as being severely underweight. This research study consisted a sample of 320 female athletes and they were looking at common

anthropometric markers when it came to an athletes' perception of their IBW while looking into their BMI, dietary restraint, menstrual function, and bone mineral density.

These researchers found that athletes who had a lower ideal body weight, exhibited a likelihood to develop a low BMI. With everything done in their study, their research allowed for the self-report on dietary restraint and menstrual dysfunction and they felt that there was an under-report on these because of the fact that they had a high percentage who displayed low bone mineral density.

Similarly, according to Laframboise, Borody, & Stern (2013), low bone mass is when ones' bone mineral density is lower than what is expected normal for the age group norms. In their particular study, they take you through 4 case studies on female athletes. All 4 of these athletes presented signs of musculoskeletal injuries.

From the overall findings of this case study, the researchers found that even though these athletes displayed musculoskeletal injuries that had accrued over time, there were other factors to take into consideration with these injuries-these all have to do with the triad. With the conditions on disordered eating, menstrual dysfunction, and low bone mineral density, the researchers note the importance of education of these components as it relates to injuries and an athlete's time and further participation within their sport.

In addition to what Rauh, et al (2014) had to contribute with menstrual irregularities and energy availability, the researchers also discussed the relationship to injury in their study. They mentioned that runners who reported menstrual irregularities, or who had a lower body mass index that was considered normal for their age had a higher risk of injury.

From their study, 42.7% of the runners had reported at least one musculoskeletal injury which had caused them to miss either a practice, or a competition. More than 40% had even missed one or more weeks, due to their injuries. Also, specifically from this study, researchers found that those injured runners lower lumbar spine had a lower bone mineral density than what is considered normal. Even more, the injured runners were found to have a lower bone mineral density for their femoral neck, trochanter, and even their whole body as well, including the lumbar spine. They suggest to promote behaviors that will allow for the optimal bone mineral accrual for those high school runners so that it serves as a protective role for reducing the risk of musculoskeletal injuries.

Preventative Measures

When it comes to the female athlete triad, there hasn't been too much research found on possible preventative measures. There has been a lot of recommendations out there, but few researches have actually been found to have been completed on it. Part of prevention can be up to a coach's attitude and knowledge of it.

In a study done by Sherman, Thompson, Sossin, & Austin (2014), researchers here were looking at the gender differences of coaching and assessing their knowledge, attitudes, and communication about healthy behaviors with their athletes. Surveys were sent out to coaches to obtain information on what they may educate their athletes on when it comes to health and performance. From the surveys that were sent out, 227 submitted answers for the survey, but only 144 had submitted fully completed surveys.

What these researchers found was that coaches felt that bone density wasn't a serious concern for the athlete's overall health, but that low energy availability was. Part of this included eating and weight-related behaviors. They found that male coaches were

more likely to be okay with athletes skipping a meal or two, and were less likely to consider over-exercising for a sport to be a threat to that athlete. They also found that male coaches perceived that having menstrual irregularities to be less harmful towards the health of the athlete. This study shows how important it is for even coaches to be trained on the female athlete triad.

From a different perspective on educating people on the triad, Brown, Wengreen, Beals, & Heath (2016) decided to complete a pilot study on the effects that peer education may have when it comes to the knowledge of the female athlete triad. Their study consisted of 29 female high school track athletes. They were weighed and measured, and completed pre- and post- surveys on the triad. Within this study, the coach that was involved had selected 6 upperclassman on the team to serve as the peer leaders. They were given the session curriculum and trained on what they would teach their peers. At the end of this study, when the post- surveys came in, 69% mentioned that they enjoyed the education on the triad, and 52% reported that they were making changes to their diet because of what they learned from their sessions. There was a high average that mentioned that the information they had received, that they would have preferred it coming from a coach, teacher, or other adult when it comes to the education of the triad.

Similar results were found when it comes to increasing knowledge on the triad in Krick, K. Brown, Ramsay, & A. Brown (2019). They found that when it came to education on the female athlete triad, athletes became more knowledgeable on it after their participation in some education on it. This particular study included 93 high school participants who watched a brief 10-minute video that was aimed at gaging the

participants knowledge on the different personal, social, and environmental influences on their behaviors.

They randomly created a control group and an intervention group when it came to distributing knowledge on the triad. Participants completed a pre-survey on the triad, and then a post-survey following the study. They found that there was a higher increase in triad knowledge with the intervention group following their study, even though their educational video on it was only 10 minutes.

Summary

The female athlete triad consists of three interrelated components: energy availability (disordered eating), menstrual irregularities, and bone mineral density. Females have come a long way, especially with the passage of Title IX, in regards to their increase of participation in athletics. But with this has come many other things as well. If females don't properly take care of themselves, they can find themselves succumbed to the female athlete triad. One component can in turn lead to another and spiral through all three leaving the athlete injured and with less participation time in their sport.

The importance on education of the triad could be very critical in a female athletes' adolescence. With knowledge of the different components and how they are interrelated can lead to changes in behavior-in hopes to ultimately lead to an overall healthy behavior. As athletes, coaches, and even parents, are educated on the triad, they can become more knowledgeable in healthy ways athletes can go through their routine to be at their optimal best for their sport. This knowledge can lead to healthier eating habits, and weight-training habits which in turn can lead to less injury for athletes during their sport season.

There will be some athletes who slip through the cracks, but as schools and coaches start to educate their female athletes on potential harms of the triad, one can hope for a healthy and full season for their athletes. To those who still may fall into the triad, more education on healthy ways to get back on track is out there.

The female athlete triad may be more serious than some people may think- especially because there are so many people who don't even know about this. With education on this, coaches, teachers, and parents, can educate their own to help their child, student, and athlete, become stronger both mentally and physically.

Chapter 4

Results, Discussion and Recommendations for Future Research

The purpose of this chapter is to present the results of the review of literature on female athlete triad and its long-term effect on high school female athletes and how these results align with the purported research questions which guided this synthesis project. In addition, recommendations for future research as it relates to the female athlete triad and its long-term effects on high school female athletes are presented.

The results of this review of literature revealed the following there can be some long-term effects for female athletes who have gone through the female athlete triad. Especially when it comes to adolescents, experiencing components of the triad can result in low bone mineral density, which can in long-term, effect the growth and musculoskeletal development of a female. A correlation with this loss in bone mineral density is the amount of time the athlete may end up participating in a sport for that season, or seasons to come.

Athletes who have gone through the triad have shown an increase of musculoskeletal injuries which have led to a decrease in amount of time spent participating in that sport for the season. Some athletes have needed a longer time to heal and to return to play as well.

Discussion

Interpretations

As part of this literature review, several research questions were posed. The first research question examined was, what are the effects of the female athlete triad on an athlete's sport injury and participation? The results in many of the research studies show

that there is a relatedness between components of the female athlete triad and injury. For example, in Rauh et al (2010), the researchers found that of the athletes who participated in nonimpact or endurance sports, almost 46% of them had a musculoskeletal injury, and those who participated in high-impact, team, or anaerobic sports, almost 33% of those athletes experienced lower musculoskeletal injuries. With injuries in mind, they also found that athletes who had a higher dietary restraint were more likely to experience musculoskeletal injuries. This also was the same when it came for menstrual irregularities-athletes who had an irregular menstrual cycle (oligomenorrhea/amenorrhea) had an increase risk to injury as well than those who had reported a normal menstrual cycle. Other researchers had found similar results. Thein-Nissenbaum, et al (2012), had reported a 63% of overall injury in relation to their study. This number included all types of injury, even if it did not cause an athlete to miss time in the sport. When it came to injury that caused lost time in sport participation, they had reported to have almost 57% of athletes who fell under this category.

The second research question that was examined was, what are the long-term health effects of the athlete? The results shown throughout some studies have to deal with bone mineral density-which in turn, can be a cause of easy injury. Laframboise, Borody, & Stern (2013) discussed how intentional or unintentional restriction of calories consumed can result on ones' body to obtain their peak bone mass. They mention that it changes a females physiological and neuroendocrine responses which can affect the production of leptin, T3, insulin, ghrelin, growth hormones, and so many more. Similar to this, Thralls, et al, (2016) discussed how low bone mineral density was related to menstrual dysfunctions, which led to a higher incidence in bone injuries. Also, Ponorac,

Paliya, and Popovic (2013), mention the importance of the female body's development during puberty in regards to developing the maximum bone mass for a female. They discuss how low-energy availability, in relationship to the triad, can pose a potential risk for a women's bone health and could possible lead to osteoporosis.

The last research questioned that was studied was, what steps can be used to educate female athletes on the female athlete triad as a method for prevention? The results from this suggest that there is a positive outcome for education on the female athlete triad. Brown, et al, (2016) found that through their research, there was an increase in triad knowledge through their peer led educational study. Even though they did not have a control group, the evidence show that the peer-led intervention had led to an increase in knowledge on the female athlete triad. Similar to this, Kricks, et al, (2019) found in their study, that even with just a 10-minute video, female athletes had shown an increase in knowledge of the triad. They also make note of the convenience of having a 10-minute informational video on the triad, mentioning how more likely coaches will utilize this because it won't take a lot of time from them.

Implications

When it comes to previous research done on the female athlete triad, there seems to be a lot of agreeance on different components of the triad. Researchers all seem to come up with very similar conclusions on how the triad can affect a female athlete. From the research gathered, the components of the triad are interrelated with each other. Energy availability can lead to menstrual irregularities, which in turn can affects ones' bone mass and further, may lead to an increase in injury among those female athletes. As physical educators, administrators, and coaches, becoming knowledgeable and up to

speed with the triad can further help to decrease the number of athletes who may succumb to the triad. It is pertinent that educators know the risks of the triad so that they can better educate their athletes on it.

There were some studies that found results slightly different in the area of energy availability. As in Rauh, Barrack, and Nichols (2014), these researchers reported at one point that their disordered eating findings weren't statistically significant among their injured runners. They felt that the self-reporting of this from athletes were not completely accurate and that athletes had under-reported.

From the results found within all of the studies, it appears that the results confirm existing theories on the female athlete triad. A lot of the research shows the how the components of the female athlete triad work. It shows that it ultimately can lead to an increase in injury for that athlete during their sport season, but it also shows that it could lead to long-term injuries like osteoporosis. Energy availability can lead to menstrual irregularities in females, which can ultimately cause a decrease in bone mass, especially during ones' adolescence when a female's bones are still growing and developing, affecting their peak bone mass.

These ultimately are practical implications-education has proven to lead to an increase in knowledge of the female athlete triad. With an increase in knowledge, athletes may become more aware of their actions and their behaviors and can make better choices for their overall health. It is practical to educate athletes on the triad-increasing their knowledge can allow them to make better and healthier choices which can leave them as a strong, healthy athlete during their sporting season.

Recommendations for Future Research

In reviewing the data base on the female athlete triad and its long-term effects on high school female athletes, the following limitations were noted regarding the studies under review. The lack of knowledge that coaches, teachers, and parents may have on the female athlete triad. The differences in the sample sizes within each research study that was reviewed-some may have been too small or too large to make specific generalizations. Another limitation to note is that participants may not have always provided truthful information, even in the studies where they were closely being monitored, they may have changed behaviors during the times when they knew they were being monitored, and even under-reported, or mi-reported different things.

Based on these limitations and other insights related to the literature the following recommendations for future research should be considered:

1. Further research on the effects of the female athlete triad.
2. Research on the female athlete triad and recovery
3. Research on the female athlete triad and education among adolescent female athletes, and how it may affect athletes-do they stray away from the triad or just become knowledgeable from it..

Summary

Overall summary

The purpose of this literature review was to determine the female athlete triad and its long-term effects on high school female athletes. Delimiting variables were used to do an exhaustive data-based search which ultimately yielded to 10 number of articles that

were chosen for this review. These articles were then systematically used to determine the female athlete triad and its long-term effects on high school female athletes.

Research revealed that the components of the female athlete triad can lead to an increase in injury for an athlete that can lead to missed time in their sport. With this in mind, adolescents are growing. Young female athletes who succumb to the triad can also face long-term consequences as well. With ones' bone mass developing in ones' youth, becoming a victim of the triad can interrupt a female's bone mass growth at its peak time, which can lead to future bone diseases like osteoporosis which is something that can make the bones more vulnerable to break.

There is still hope though-through further research, there is hope with education of the female athlete triad. With the research found involving the education of high school female athletes, it showed an increase in knowledge when athletes participated in these studies. With an increase in knowledge in this content area, one can hope for a decrease in the number of athletes who fall to the triad.

References

- Brown, Wengreen, Beals, & Health. (2016). Effects of peer-education on the knowledge of the female athlete triad among high school track and field athletes: A pilot study. *Women in Sport and Physical Activity, 24*, 1-6.
<https://dx.doi.org/10.1123/wspaj.2014-0058>
- Krick, Brown, A., & Brown, K. (2019). Increased female athlete triad knowledge following a brief educational video. *Journal of Nutrition and Behavior, 51(9)* 1126-1129. <https://doi.org/10.1016/j.jneb.2019.05.600>
- Laframboise, Borody, & Stern. (2013). The female athlete triad: a case series and narrative overview. *Journal of the Canadian Chiropractic Association, 57(4)*, 316–326. Retrieved from
<https://brockport.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=97583158&site=ehost-live>
- Melin, Tornberg, Skouby, Møller, Faber, Sundgot-Borgen, & Sjödin. (2016). Low-energy density and high fiber intake are dietary concerns in female endurance athletes. *Scandinavian Journal of Medicine & Science in Sports, 26(9)*, 1060–1071.
Retrieved from
<https://brockport.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=117343099&site=ehost-live>
- Ponorac, Palija, & Popovic. (2013). Women and Sport. *Sport Logia, 9(1)*, 1-7.
<https://doi.org/10.5550/sgia.130901.en.001P>
- Rauh, Nichols, & Barrack. (2010). Relationships among injury and disordered eating, menstrual dysfunction, and low bone mineral density in high school athletes: A

- Prospective Study. *Journal of Athletic Training (National Athletic Trainers' Association)*, 45(3), 243–252. Retrieved from <https://brockport.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=51535603&site=ehost-live>
- Rauh, Barrack, & Nichols. (2014). Associations between the female athlete triad and injury among high school runners. *International Journal of Sports Physical Therapy*, 9(7), 948–958. Retrieved from <https://brockport.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=101816215&site=ehost-live>
- Thein-Nissenbaum, Rauh, Carr, Loud, & McGuine. (2012). Menstrual irregularity and musculoskeletal injury in female high school athletes. *Journal of Athletic Training (National Athletic Trainers' Association)*, 47(1), 74–82. Retrieved from <https://brockport.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=73531589&site=ehost-live>
- Thein-Nissenbaum, Carr, Hetzel, & Dennison. (2014). Disordered eating, menstrual irregularity, and musculoskeletal injury in high school athletes. *Sports Health*, 6(4), 313–320. <https://doi.org/10.1177/1941738113498852>
- Thralls, Nichols, Barrack, Kern, & Rauh. (2016). Body mass-related predictors of the female athlete triad among adolescent athletes. *International Journal of Sport Nutrition & Exercise Metabolism*, 26(1), 17–25. <https://doi.org/10.1123/ijsnem.2015-0072>

Appendix A

Author	Title	Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Thein-Nissenbaum, J. M., Rauh, M. J., Carr, K. E., Loud, K. J., & McGuine, T. A.	Menstrual Irregularity and Musculoskeletal Injury in High School Athletes.	<i>Journal of Athletic Training (National Athletic Trainers' Association)</i>	The purpose of this study is to determine the prevalence of and the relationship between menstrual irregularity and musculoskeletal injury in high school athletes.	The final sample had 249 female athletes who competed in a variety of different interscholastic sport teams. Data was collected from three different high schools. Data was collected at the end of each sports season.	Students filled out a questionnaire. They were analyzed on their menstrual irregularity in comparison to their musculoskeletal injuries through these questionnaires. They survey they took collected information on the type of injury, the number of sport participation days that they missed, and their menstrual history over the year. Surveys that were incomplete were excluded. Statistical	When it came to MI, 19.7% of students were found with this. With INJ, 63.1% of students were found to encounter these. Those who had reported MI had a higher percentage of a severe injury. Athletes with MI were 3 times as likely to experience an injury that resulted in a loss of more than 7 days of missing their sport.	The incidences of MI and INJ in this study were considered high. It is recommended to increase the education and knowledge on MI and the possibility of its effects on injury with female high school athletes.

					comparison was performed by using a 1-way analysis and Bonferroni post hoc pairwise comparisons. Chi-squared analysis were used as well.		
Rauh, M. J., Barrack, M., & Nichols, J. F.	Associations Between the Female Athlete Triad and Injury Among High School Runners	<i>International Journal of Sports Physical Therapy</i>	The purpose of this study was to determine the associations between the female athlete triad and this risk of lower extremity musculoskeletal injury among adolescent runners.	89 female athletes involved in cross-country and track in southern California were monitored throughout their sport season for lower extremity musculoskeletal injuries. The data that was collected included injury reports, eating disorder examination questionnaire (EDE-Q), a questionnaire on	Independent t-tests and chi-square tests were used to compare demographic, physical, and menstrual characteristics with injured and non-injured athletes. Analysis of covariance was used to compare the EDE-Q scores.	42.7% (38) of the runners experienced at least one lower extremity musculoskeletal injury during their sport season. Also, a low BMD level relative to age was associated with an increased occurrence of musculoskeletal injury during the sport season. Majority of the injuries were minor ones. Injured runners had a lower	The authors guess that the components of the triad do contribute to musculoskeletal injury due to the weakening of the tissue. It is recommended that deeper examination of the triad's component with the athlete's decision to return to play be looked at. Also, more studies with larger sample sizes are recommended. Lastly, they suggest that intervention studies be done to help educate athletes, parents,

				menstrual history and demographic characteristics, a dual energy x-ray absorptiometry scan that measured the bone mineral density which was used to scan the athlete's spine, proximal femur, and tibia/fibula. and body composition, body fat percent, and lean body mass.		BMD at their spine, hip, and whole body compared to the non-injured runners. Results show that runners who had reported oligo/amenorrhea, or whose BMD was low for their age, indeed show an increased risk of injury.	coaches, and healthcare professionals on the triad components, and to promote health eating and training behaviors.
Rauh, M. J., Nichols, J. F., & Barrack, M. T.	Relationships Among Injury and Disordered Eating, Menstrual Dysfunction, and Low Bone Mineral Density in High School	<i>Journal of Athletic Training (National Athletic Trainers' Association)</i>	The purpose of this study was to examine the relationship among disordered eating, menstrual dysfunction, and low bone mineral density and musculoskeletal	The sample consisted of female athletes from 8 different sports from 6 high schools. Athletes were ages 13-18 (depending on the age of menarche). Questionnaire	Analysis of covariance was used to control for chronological age, gynecological age, lean tissue mass, and sport group. Crude odds ratios and confidence intervals were also used for	Of the athletes that participated, 163, 61 (37.4%) had incurred 90 musculoskeletal injuries. With those that had a history of oligo/amenorrhea during the past year, there was an association	It is recommended to conduct further studies on the relationship between the triad and sport injuries in high school athletes. It is also suggested to do research on injuries in individual sports to see if certain ones

	Athletes: A Prospecti ve Study		letal injury among girls in high school sports.	ire's using the EDE-Q were taken. Of the 589 athletes who completed this, 170 were randomly chosen to receive a bone mineral density scan. Injuries were also recorded throughout the season.	analyzing injuries.	with the occurrence of musculoskel etal injury during the sport season. Findings confirm there is a relationship between the triad components and injuries.	are at a greater risk. The lastly suggest that studies may be needed to determine if the triad components alone lead to injury, and to determine if other variables may have an effect.
Thein- Nissenb aum, J. M., Carr, K. E., Hetzl, S., & Denniso n, E.	Disordere d Eating, Menstrua l Irregulari ty, and Musculos keletal Injury in High School Athletes	<i>Sports Health</i>	The purpose of this study is to compare the prevalence of DE, menstrual irregularity , and musculoske letal injury among high school female athletes in OCP and non-OCP users.	The people involved in this study completed the EDE-Q questionnai re and the Healthy Wisconsin Female Athletes Survey (HWHSFA S). Then, athletes were grouped by OCP and sport type. Participants reported injuries to researchers at the end of the	Analysis of DE and EDE-Q between the 2 groups were performed with the Fisher exact test that controlled for age and sport type.	14.8% of participants were OCP user's and there wasn't a difference in MI and INJ among groups. There was a higher number of disordered eaters within the OCP users- OCP users were two times as likely to be considered disordered eaters.	They recommend for doctors to be diligent in screening for the triad components for athletes who are OCP users and for disordered eating..

				season-injuries reported did not need to have been reported to coaches or trainers.			
Brown, K. N, Wengren, H. J., Beals, K. A., Heath, E. M.	Effects of Peer-Education on Knowledge of the Female Athlete Triad Among High School Track and Field Athletes: A Pilot Study	<i>Women in Sport and Physical Activity</i>	The purpose of this study is to assess the risk of the female athlete triad, and to pilot a peer-led triad educational intervention.	49 athletes of a high school track team were consented to participate. 29 of these completed a paper-based, end-of-the-season survey that assessed their knowledge change in the triad and risks. The coach selected juniors and seniors to be the peer-leaders for the educational intervention. They were given information on the curriculum and participant	Paired t-tests were utilized to look at changes in the knowledge of body image. Mann-Whitney test and Wilcoxon test were used. Chi square distributions with the Fisher's exact test were used to assess the association between variables. Triad knowledge was assessed by summing the scores from each of the 10 questions that participants answered.	Of the 29 participants, 2 had reported stress fractures, but 6 athletes experienced shin splints. 54% reported menstrual irregularities, and 23% reported a history of amenorrhea.	Triad risk factors were prevalent in this study. It is recommended for further research while utilizing a control group to determine the interventions impact with behavior changes. They recommend that coaches have a positive environment that support athletes in developing a healthy body image and that athletes should receive nutrition and triad education.

				workbooks. They were trained before they would teach their peers. There were 4 sessions they taught. Participants completed a survey, was measured for height and weight, and completed a postintervention survey.			
Thralls, K. J., Nichols, J. F., Barrack, M. T., Kern, M., & Rauh, M. J.	Body Mass-Related Predictors of the Female Athlete Triad Among Adolescent Athletes	<i>International Journal of Sport Nutrition & Exercise Metabolism</i>	The purpose of this study was to assess the relationship between common anthropometric markers (ideal body weight-IBM) and the triad components,	The study was a cross-sectional design. There were 320 female high school athletes between the ages of 13-18 years. There was consent that was needed prior to the study from participants. They completed the EDE-Q	Descriptive statistics were measured. Spearman's rho correlation was also used.	Athletes who had an ideal body weight of less than 85% were more likely to report MD. Those with an IBW of less than 85% were also more likely to show lower bone mineral density. Using the Hamwi formula, BMI percentiles	Researchers mention that participants may have underreported dietary habits to hide their behaviors/motivations. The recommend additional research be done using these same formulas.

				and a menstrual history questionnaire. Height and weight were measured along with scans that assessed their body composition.		were greatly associated with MD and low BMD. Underweight categories were not directly related to dietary restrictions.	
Melin, A., Tornberg, A.B., Skouby, S., Moller, S.S., Faber, J., Sundgot - Borgen, J., & Sjodin, A.	Low-energy density and high fiber intake are dietary concerns in female endurance athletes.	<i>Scandinavian Journal of Medicine & Science in Sports</i>	The purpose of this study was to describe dietary characteristics of athletes with low energy availability and or functional hypothalamic oligomenorrhea or amenorrhea	25 participants were recorded for 7 consecutive days to calculate their energy available, during their everyday routines. Dietary intake was taken based off a 7-day food record. Food group was analyzed by calculating the number of servings in the 9 different food groups	Statistical procedures were performed using SPSS. Data was summarized as mean standard deviation.	With BMI, body composition, and exercise between participants, there was no difference found. Participants with low energy availability displayed a higher training and exercise expenditure.	The recommend nutritional intervention for athletes who display risky behaviors. The increase drive to keep a low body weight can increase risk of LEA. For athletes who need to lose weight, it is recommended that they be provided counseling and a nutritional plan with safe guidelines.

				over their 7 days.			
Laframb oise, M. A., Borody, C., & Stern, P.	The female athlete triad: a case series and narrative overview	<i>Journal of the Canada n Chiropr actic Associat ion</i>	The purpose of this study was to illustrate the differences of the female athlete triad, and to also inform the consultant of the potential of this condition.	The methods included the case study of 4 female athletes from ages 16-27 with varying degrees of athletics.	The athletes who participated had experienced some sort of muscular pain or injury. After seeing different specialist, researchers looked into their menstrual histories and did physical inspections with a medical physician if there was suspicion of the female athlete triad.	It was found that the four participants did see aspects of the female athlete triad.	The authors recommend that if an athlete displays properties of one aspect of the triad that they should be tested for the other aspects of it. They also recommend training and education for parents and coaches so they can understand more the components of the triad. They also mention how health care practitioners should be aware of the different clinical aspects of the female athlete triad.
Kricks, R., Brown, A., Brown, K.	Increased Female Athlete Triad Knowled ge Followin g a Brief Video Educatio	<i>Journal of Nutritio n Educati on and Behavio r</i>	The purpose of this study was to assess changes in triad knowledge among female	High school female athletes were randomly assigned to the interventio n group or	Knowledge was assessed by using questions on a Likert scale.	Average preintervent ion triad knowledge was low. After the intervention, triad knowledge increase.	Due to the increase of knowledge of the triad, further education is recommended .

	nal Interventi on		high school athletes after participatin g in a brief triad educational interventio n.	control group. Participants would answer questions on a Likert scale, then watch an educational video and answer the questions again.			
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