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Brown, Phoebe, "Mental Health as a Predictor of Bone Stress Fractures in Female Collegiate Athletes: A Literature Review" (2022). *University Honors Theses.* Paper 1167.
https://doi.org/10.15760/honors.1244

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Mental Health as a Predictor of Bone Stress Fractures in Female Collegiate Athletes - A Literature Review

by:

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An undergraduate thesis submitted in partial fulfillment of the

requirements for the degree of

Bachelor of Science

In

University Honors

And

Pre-Clinical Health Sciences

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2022

Author's Note

Throughout this thesis, there are gender and sex terms used to describe specific populations. For clarity, the terms "female" and "woman" are used to indicate those persons assigned female at birth. However, I have used the term "female" instead of "woman" wherever possible as to avoid exclusion of those athletes who identify as women and were assigned male at birth. Also, there may be athletes on mens' athletics teams that were assigned female at birth, and the research below can be useful to them as well. Non-binary and intersex athletes are also not addressed, but the information on mental and physical health also applies to them. Gender, sex, and pronouns should be respected in every space, including the athletic and medical communities. I acknowledge that these terms are inherently inadequate and must be improved upon by our scientific community.

Introduction

Collegiate athletes are told that injury comes with sport. It is expected that every athlete will experience an injury at least once during their collegiate career, but should that be true of stress fractures?

A stress fracture is a small crack in the bone caused by repeated impact or mechanical loading, such as running long distances or large amounts of jumping. This thesis will focus on female athletes because they disproportionately experience stress fractures. While male athletes have considerable rates of stress fractures compared to the general population, female athletes have double the rates of males depending on sport comparison. For example, male athletes in track and distance running have higher rates of stress fractures than male athletes in other sports. However, female athletes still have higher rates across all sports. In the NCAA, 20% of female

athletes get stress fractures annually (Rizzone et al., 2017). This means that 1 in 5 female athletes will sustain a stress fracture every year, which is an extremely high number considering that stress fractures are capable of negatively impacting entire seasons, college experiences, and quality of life.

This percentage is not acceptable because stress fractures are preventable. So how do they happen? Factors such as nutrition, bone health, menstrual health, and training intensity have all been documented scape-goats for stress fracture occurrence. While these factors will be accounted for in this thesis, another major contributor has been brushed under the rug, left to be dealt with last: mental health.

This thesis will investigate the impact mental health has on preventing and contributing to stress fractures in collegiate athletes. Throughout this literature review, strategies for protecting the holistic health of female athletes will also be explored. After all, when a physical injury is diagnosed and treated it heals much faster than if it is continued to be put under the stressors of vigorous training and competition. Should we not approach mental health in the same way?

We will dive into these various contributing factors of stress fractures and how they are impacted by mental health. While all of these factors are important parts of health, they stop short of representing the whole athlete by excluding and diminishing the impacts of mental health.

I. RED-S and the Female Athlete Triad

A factor of stress fracture rates only recently addressed is energy availability (EA). Low EA occurs when energy intake is lower than energy output, and has only just begun to be studied

as a factor of health in athletes within the last 30 years. Symptoms differ from person to person, but generally include drowsiness, irritability, concentration difficulties, depressive episodes, and higher anxiety and stress levels. Previously thought to solely be a side effect of intense training, EA has been misdiagnosed for decades. Many athletes will often conceal when they are feeling tired in order to maintain a "tough" demeanor. Also, due to its subjectivity, EA is difficult to measure. However, a few definitions and screening tools have been developed to identify EA.

Relative Energy Deficiency in Sport (RED-S) is defined as affecting any athlete (male or female) and is characterized by low EA due to a caloric deficit (Mountjoy et al., 2014). RED-S is a large predictor of stress fractures because it is most often developed due to insufficient fueling and recovery, which are necessary for bone health (Mountjoy et al., 2014). Athletes can be screened for RED-S via survey or self-report fatigue levels on a weekly basis to their coaches and/or sports medical staff.

The Female Athlete Triad (FAT) is a combination of amenorrhea, low EA, and osteoporosis, although some would add disordered eating (Barrack et al., 2014). Amenorrhea is the loss of menses, or irregular menstrual cycles. It can be triggered by insufficient fueling and stress. Osteoporosis is a condition in which bones become brittle and weak because the bone tissues are not being replaced. Osteoporosis will be covered in more detail in Section IV (see below).

Disordered eating was originally one of the triad, but was "updated to low EA with or without an eating disorder" in 2007 (Nose-Ogura et al., 2018, pp. 1007-1008). This expands the triad to include those athletes who may not have an eating disorder, but who are experiencing low EA. Eating disorders or disordered eating are usually experienced along with RED-S, which supports the theory that mental health is the first factor to evaluate when an athlete reports low

EA or even a stress fracture. Also, low EA could be misdiagnosed as, or a comorbidity of, anxiety and depression. This makes screening for low EA critical in mental health support for an athlete.

Insufficient fueling and over-training both contribute to amenorrhea, which has been reported to be much higher in female athletes than in the general population of women (Nose-Ogura et al., 2018). Amenorrhea is a dangerous illness to experience repeatedly or for an extended amount of time as it can lead to anovulation, infertility, osteoporosis, and osteopenia. Also, people suffering from amenorrhea "present significantly higher [rates of] depression and anxiety and also sexual problems" compared to healthy people (Meczekalski et al., 2014, p. 1054). Amenorrhea may also introduce anxiety and "an altered perception of self-normalcy" (Mountjoy et al., 2014, p. 92). As with low EA, if an athlete is experiencing amenorrhea, they need to be screened for both depression and anxiety.

In the past, oral contraceptive pills (OCPs) have been prescribed to athletes experiencing amenorrhea. However, the use of OCPs for those athletes experiencing amenorrhea has become controversial (Chen et al., 2013). While OCPs normalize menses, they also obscure the body's ability to create a menstrual cycle organically. This means that if an athlete is taking OCPs they will most likely experience regular menses, even if their body is not able to support a regular cycle. As amenorrhea is one of the first signs of insufficient fueling, a cycle supported by OCPs may conceal an undernourished athlete. Athletes taking OCPs should have their bloodwork and caloric intake checked in order to assess menstrual health.

Athletes should also be screened for both RED-S and FAT regularly so as to avoid creating a large caloric deficit and protect against future injury and osteoporosis (Javed et al., 2013). Koltun et al. compared assessment tools for both RED-S and FAT (2019). These

assessment tools had a variety of items they screened for, including 2 disordered eating questionnaires. The results showed that more athletes were in need of increased surveillance after using the FAT assessment than those who used the RED-S assessment. This infers that using an assessment based on triad symptoms may be more effective at detecting a wider range of potential at-risk athletes than a RED-S-based assessment. Unfortunately, assessments are not a regular practice in the majority of university athletic departments (Kroshus, 2016).

II. Nutrition and Disordered Eating

Nutrition and proper fueling are key to athletic performance. This is a well known, well studied fact. Unfortunately, nutrition in athletes is plagued by disordered eating, clinical eating disorders, and misinformation, especially pertaining to female nutritional needs.

If a female athlete is not recovering properly through adequate fueling and nutrition, glycogen stores will not be replenished (Manore et al., 2007). This means that the athlete will most likely experience low energy and amenorrhea.

Disordered eating (DE) is a continuum, ranging from mismanaging a seemingly healthy diet, to clinical eating disorders (EDs). DE can be accidental, periodic, or a stand-alone event, and can be addressed by a nutritionist. DE is an underlying factor for RED-S, but does not immediately predict an ED, as DE “may occur without such a psychological overlay” (Mountjoy et al., 2014, p. 92). EDs are much more serious and need to be addressed by a mental healthcare professional as EDs can be life-long illnesses that need to be managed with therapy. It’s very important to know which one an athlete is experiencing, however it is difficult for an unqualified person (coach, some athletic trainers, teammates, friends, family members) to tell the difference

between EDs and DE. Although this is not a conversation heard very often amongst athletes, DE affects about 20% of adult female elite athletes (Mountjoy et al., 2014).

If an athlete is underfueling, both their macronutrients and their micronutrients will be under the recommended value (Manore et al., 2007). Both are essential for bone health and formation. Athletes are under pressure to look "athletically capable" and this adds stress to decisions around fueling. However, it is nearly impossible for athletes to overfuel due to the amount of calories they burn every day for extended periods of time. For example, long distance runners are generally faster when they are lighter, but there is a unique, individual ratio of lightness to speed (race weight) for every athlete that will differ from every other athlete. Fueling decisions that are influenced by the race weights of other athletes can lead to unhealthy dieting and weight loss that results in underfueling.

Unfortunately, runners who are thinner have historically been assumed to be faster than heavier set runners based on body composition alone, and this belief has led to many eating disorders in collegiate runners who are afraid to gain weight. However, it is difficult for a runner who is burning calories every day to overfuel. This is a facet of the stress fracture epidemic that needs to be addressed with athletes: they are not going to lose fitness by properly fueling, and gaining weight in a healthy way will not make them perform poorer. This type of misinformation is not just spread within athletics, but in Western society as a whole. This leads to exposure of negative self-image from multiple sources (social media, advertisements, social environments, relationships, etc.,).

Historically, coaches in some sports (including those with the highest rates of stress fractures) have mandated competition weights for their athletes. These weights are not prescribed by medical professionals, but by the coaches themselves. This means that if the athlete did not

obtain their race weight before competition, they were excluded from participation or even punished in some other way. For example, in 2021 six female athletes from the University of Oregon track and field team came forward to share their experiences with the program (Goe, 2021). They stated that their coach tracked their body-fat percentages, and that the approach the program takes toward weight and body image put them at a higher risk of developing eating disorders. Members of the team reported starving themselves before their scans because they were so afraid of reporting a "high" body-fat percentage. If they repeatedly got a high percentage, they were required to do additional cross training, and their teammates knew why. The team did have nutritionists, but the women who came forward said that the nutritionist provided by their program was recommending that they have lower body-fat percentages than the recommended range of 14-20%. The article concludes that while "body weight and body fat percentage do factor into athletic performance […] several sports psychologists see red flags in approaches such as the one Oregon uses, particularly with women college athletes" (Goe, 2021, para. 83). These practices have not been monitored or penalized by higher powers (i.e. NCAA), and enforcement of race weights by coaches are still occurring within universities.

III. Stress Fracture Rates Depending on Sport

Stress fracture rates differ depending on sport type as well as sex. Female athletes have almost two times higher rates of stress fractures than male athletes (Rizzone et al., 2017). In comparison to repetitive, low impact loading sports, such as long distance running, "high-impact or odd-impact loading (basketball, soccer, gymnastics, volleyball, jumping sports, racket sports, martial arts, step aerobics, speed skating) had higher bone density" (Chen et al., 2013, p. 177).

The sports with the highest rates of stress fractures are women's cross country, women's gymnastics, and women's outdoor track, in that order (Rizzone et al., 2017). These sports are also highly "aesthetic" or "lean" sports that have a high incidence of eating disorders. The repetitive muskuloskeletal loading, in addition to higher rates of EDs and body dysmorphia put "aesthetic" sports at a higher risk for stress fractures.

In surveys from 2012, only "a third of athletes could identify the relationship between menstrual dysfunction and poor bone health", almost half of athletes think that amenorrhea is normal, "particularly in lean sports", and "22% of lean sports athletes report that they would not seek treatment for amenorrhea, compared with 3.2% of athletes participating in nonlean sports" (Javed et al., 2013, p. 1000). Through education on nutritional needs and fostering an environment of body acceptance, athletes will be better equipped to manage their fueling. Additionally, sport type and social norms within each sport type need to be addressed.

IV. Bone Health

While a healthy balance between exercise and nutrition can actually improve bone health, many athletes are on the brink of overtraining and underfueling, leading to low EA, which is "now recognized as an independent factor of poor bone health" (Mountjoy et al., 2014, p. 93).

Low bone mass density (BMD) is characteristic of bone stress fractures. According to Goolsby and Boniquit, "52% of adults older than 50 years have low bone mass at the femoral neck or lumbar spine" (p. 110) which are common places for stress fractures in athletes (2017). Around the age of 25, bones have grown as much as they are going to grow, so it is vital that collegiate athletes' bones are protected. Bone loss in athletes experiencing chronic amenorrhea or low EA may be irreversible (Keen & Drinkwater, 1997). This sets these athletes up for

increased risk of osteoporosis and increased incidence of serious fractures (i.e. in the hip or femur) later in life.

Around 80% of people with osteoporosis in the United States are women (The Office of Women's Health, 2019). This means that female athletes are more likely to develop osteoporosis than their male counterparts. Osteoporosis can be developed at any age, but is generally seen in older people. Bone health in your twenties affects bone health and mortality rates in your eighties.

Unfortunately, recurrence rates of stress fractures in female athletes are also high. In a study done in 2017, Rizzone et al. found that "22% of stress fractures were recurrent, and 21% resulted in season-ending injuries"(p. 973). The highest proportions of recurrent stress fractures were in the metatarsals, lower back and pelvis, and tibia. Lower back and pelvis fractures are particularly dangerous, and pose an increased risk of major fracturing in later life.

Goolsby and Boniquit found that bone health can be optimized if female athletes are screened for healthy Vitamin D, calcium, ferritin and hormone levels (2017). If bones have access to micronutrients that help them to grow strong and the body is allowed to recover properly, bone mass density can increase. Screening for Vitamin D, calcium and ferritin via blood tests and nutritional surveys should be implemented, especially for female athletes competing in lean sports, or if the athlete has had a history of stress fracture, eating disorders, disordered eating, or amenorrhea.

V. Mental Health

Mental health in athletes has long been studied in regards to performance-related anxiety, but much fewer studies have been done concerning mental health in injury prevention. However,

we do know that they are linked. Mountjoy et al. found that “psychological stress and/or depression can result in low EA and EDs and can also be a result of low EA” (2014, p. 92). This means that psychological illnesses can either be the cause or the result of RED-S. In order to diagnose and treat a patient, it is necessary to know which (RED-S or psychological illness) came first, or if they are comorbidities. Currently, most research concerning stress fractures, low EA, and RED-S suggest psychological examination for EDs, but do not usually mention examination for depression or anxiety.

Additionally, athletes at universities are also full-time students. The stress and responsibilities of school are not diminished for student athletes. Athletes may develop anxiety, depression, eating disorders, or some combination of the three under the workload of education and competition. Eating disorders in particular have the effect of making the individual feel as though they have complete control over something in their life. However, it is the feeling of lacking control that is the underlying cause of most eating disorders (Froreich et al., 2016).

Anxiety and depression during preseason increase the risk of injury in-season (Li et al., 2017). Yet in-depth screening for anxiety, depression, or any other mental health concerns is not a standard practice for preseason physicals (Kroshus, 2016). This has been attributed to many varying factors including lack of resources and funding.

In Kroshus’s study, only 39% of the respondents had a written plan for identifying mental health concerns in their student athletes. Less than half had a written plan or verbal tool for “disordered eating (44.5%), depression (32.3%), or anxiety (30.7%)”, even though having a written plan is one of the highest predictors of screening for mental health (Kroshus, 2016, p. 392).

Javed et al. recommend that screening for mental illnesses is necessary for predicting who will experience the Female Athlete Triad, and that self-image and disordered eating are directly linked to insufficient fueling and energy deficiency (2013). Therefore, athletes should be screened regularly for mental as well as physical signs of potential stress fractures, as mental and physical health are not mutually exclusive.

Conclusion

Stress fractures are so common that most collegiate female athletes will experience at least one in their career. Eating disorders, amenorrhea, low energy availability, and low bone mass density all contribute to higher risk of stress fractures.

Pressure from social contexts, performance outcomes, and inappropriate coaching can lead to unhealthy habits that result in the previously listed risk factors.

Depression, anxiety, and eating disorders need to be screened for by sports medical staff, and treated by a mental healthcare professional. Screenings would be most useful after pre-season training has ended, as most stress fractures are acquired during pre-season, and depression and anxiety in the pre-season correlate with higher risk of stress fractures in-season.

Screening tools and written plans for mental health screening are necessary, and need to be created with the assistance of a mental healthcare professional.

Future research should test if there is a decrease in stress fracture rates at an institution after either a mental healthcare professional was added to the in-house sports medical team, or a mental health screening protocol was newly enforced.

A survey of female collegiate athletes self-reporting a mental illness preceding their stress fracture(s) could also be a useful addition to this body of research.

Recommendations

Portland State University (PSU) currently has neither an in-house mental healthcare professional nor a nutritionist for student athletes. Immediacy and ease-of-access are incredibly important when it comes to caring for mentally ill people. From the research reviewed here, it is recommended that at least a mental health care professional be provided on campus specifically for student athletes.

Secondly, the screenings that are performed at annual physicals need to be compared to previous years' screenings to check for changes in mental health. These screenings are not as accurate or impactful as an in-person diagnosis by a professional, but they are at the very least a preliminary baseline that can be performed by sports medical staff. However, the purpose of a baseline is to compare it to updated information, and therefore must be compared to any new screenings.

Lastly, improved mental health care (and consequently improved mental health) can reduce the rates of stress fractures currently seen in female athletes, which would reduce the time and resources spent on MRIs, X-Rays, physical therapy appointments and consultations. While an in-house mental health care professional does require resources, it would be more than made up for by the reduced rates of stress fractures due to decreased impacts of mental illness.

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