

Components of a Proper Warm-up  
For Active Adolescents: A Literature Review

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### **Abstract**

**Background:** Through a previous project my goal was to research and understand cultural identity. Through that project I found I wanted to help as many people as I can and it became a goal to research the adolescent age group.

**Body:** The purpose of this project was to review existing literature and come to a conclusion about proper warm-up components and techniques in adolescent sports and physical activity that help to lower the chance of injuries. The leading cause of injury in adolescents is sports, so the focus is to help decrease the amount of injuries in adolescent sports.

**Methods:** Articles used in this review include those with both females and males participating in diverse sports, recreational and intermediate level sports, as well as physical education class level of activity.

**Results and Conclusion:** A structured dynamic warm-up led by an adult is the most beneficial warm-up for preventing adolescent injuries. The warm-up should consist of stretching, strengthening, balance, sport-specific agility, and landing techniques. This will prepare the body for the specific sport or exercise. The literature on this topic is a good foundation but much more research focused on gender differences and different level of competition still needs to be completed.

## **Background**

While thinking about cultural identity during a course assignment I came to the conclusion that cultural identity is not only about the culture surrounding the person, but it is also about the individual person and what has shaped them to be the person they are. Each and every person has a different cultural identity that is molded and sculpted by the people and events that surround them throughout their lifetime. Cultural identity has the ability to change overtime due to what the individual chooses to do with his or her life. I believe this is the most unique aspect of cultural identity. Some people may be inadequately influenced when they are younger and after they fully mature, they decide they do not want to be that person anymore. Especially here in the United States, we are lucky enough to be able to choose what we want to do with our lives. Sometimes people do not fully know their cultural identity until they mature and really think about who they are and who they want to be. It was my goal through the previous course project to find my true cultural identity and I believe that project helped me do just that. I started thinking about exercise and sports and how these things have always been a huge part of my life.

My previous research made me realize that I want to learn about the body and how it functions when you move. Throughout my research and completion of the project, I found that I enjoy researching topics related to the human movement and it truly does fascinate me. I also realized with the project that many people think sports are just sports, but I believe that sports are a great way to build character, help kids figure out how to set goals, achieve those goals, and increase self-esteem along with other numerous health benefits. With this being said we want kids to be active early in life and continue to be active as long as they can.

After being engaged in research on this topic for some time, I realized I want to be able to use the knowledge that I gain from my undergraduate degree and physical therapy school and

help people better their lives. Whether that is teaching people about the advantages of dynamic stretching for a warm up or helping an elderly individual increase his or her function in their activities of daily living. I have always enjoyed helping people when I can, and this project only helped confirm that I want to help as many people as I can in not only my career but also my life as a whole. Understanding and defining my cultural identity led to researching different types of stretching because I truly want to help educate people on what is best for their bodies and specifically what is best for our bodies when we are young.

### **Introduction**

Human movement has been looked at from a variety of specialties such as psychology, kinesiology, biology, and many others (Gavrila, 1999). It was fascinating to find this article because I want to look at human movement from a scientific discipline and apply it to a different age group than what is typically focused on. It was exciting to find that other people are interested in human movement from more than one aspect. It is extremely important to look at human movement in more than one age group and more than one specialty because movement affects all people during all parts of their life. Currently, most research is being done with the elite athlete population because that is where a large majority of the money is (Readdy, 2015). Unfortunately, the focus should be shifted to youth and recreational athletes because this is the level that the majority of the active population is. If the focus is on youth and recreational athletes, we can hopefully prevent many injuries and keep our young population active. This is where everyone starts in the athletic career, so this is also where I believe the research needs to start. The best way to start exercise is with a proper warm-up that includes a general light aerobic activity and a flexibility component (Houglum, 2010). This should be at the beginning of every practice, game, or workout, so why not start the research here?

There are many aspects to a proper warm-up, but the first component is the type of warm-up that should be conducted. Some options for a warm-up include: a static warm-up, a dynamic warm-up, or proprioceptive neuromuscular facilitation (PNF). A static warm-up would consist of a stationary position and holding a stretch for a certain period of time. An example of this would be standing and bending over, touching your toes, and holding for 10-30 seconds (Kovacs, 2010). A dynamic warm-up would consist of active moving and stretching at the same time. With the dynamic warm-up the person is still getting the necessary stretch, but they are doing it in a more complex way. A dynamic warm-up would include movements that lengthen the muscle then require the muscles, tendons, and joints to produce a force in the stretched position. An example of this would be a walking lunge (Kovacs, 2010). The other option would be to conduct PNF stretching prior to exercise. PNF stretching consists of a combination of active and passive stretching and is useful for gaining range of motion. This type of stretch includes two technique patterns: agonistic and antagonistic which help muscles in different ways (Houglum, 2010).

According to the Mayo Clinic, static stretching can be a key part of exercise. However, they recommend a warm up of 5-10 minutes of light activity before stretching or to even reserve stretching for after a workout. Houglum (2010) also confirms that static stretching is important for exercise and athletes, but it should be done post exercise to stretch the muscles out after being used.

Mark Kovacs, the author of the book, *Dynamic Stretching*, agrees that static stretching has its benefits, but prefers dynamic stretches pre-exercise. He prefers dynamic for several reasons. These reason include: improving strength, muscular endurance, flexibility, and coordination. However, one of the main reasons is that dynamic stretches mimic movements and muscle recruitment patterns of the sport or activity so it better prepares the body for the event. If

the body is prepared for the specific movements, the athlete will be able to perform better during the competition (Costa, 2014; Kovacs, 2010; Meroni, 2010). Kovacs (2010) talks about how important a dynamic warm-up is for people from the recreational level up to the professional level. A warm-up for a recreational athlete is going to differ a lot from that of a professional athlete, but both will consist of similar movements and overall ideas.

After researching and comparing scholarly articles about static and dynamic stretching in a general population, the literature supports that dynamic stretching pre-exercise is more beneficial to the individual than static stretching when preparing for practice or competition. There are many aspects of dynamic stretching that benefit the body pre-exercise. It has been found that static stretching pre-exercise can sometimes decrease the athlete's performance in certain areas; such as strength, power, and speed in activities lasting 60 minutes after stretch (Young & Behm, 2003). If power athletes, such as a sprinter, were to static stretch before an event, that athlete would lose the power they need to burst out of the blocks and the speed they need to win their race. A football lineman needs strength and quickness to keep the opponents away from the quarterback. If the lineman were to static stretch before the game, he would lose some of his strength and quickness and not be able to hold the opponent back as well. Another example would be a volleyball player static stretching before a game. The volleyball player needs power to jump up and hit a ball and static stretching would decrease this power, resulting in a lower jump. When an athlete is trying to perform at their best, it is probably not the best decision to statically stretch before an event. Therefore, a dynamic warm-up should be completed prior to exercise and a static warm-up should be completed post exercise.

There are special circumstances where dynamic stretching might not be the proper choice. In individuals who are unfit or who are just beginning physical activity for the first time,

static stretching may be advised. This will allow the individual to slowly progress into a harder and more technical warm-up. Static stretching will decrease the soreness of a beginner and they will be more likely to return the next time. These are special circumstances and many other aspects of a workout would also be different for these individuals (Prentice, 2016).

This conclusion about dynamic warm-ups led to me wanting to narrow my focus and realize it is important to research the adolescent age group because almost every athlete starts at this level. This review is focused on males and females who compete at the recreational, intermediate, or competitive level of sport. It looks at many different types of injuries from mild to severe. The purpose of this project is to review existing literature and come to a conclusion about the proper dynamic warm-up components and techniques that should be specific to adolescents involved in sport and physical activity.

### **Body**

According to World Health Organization (WHO), “adolescence begins with the onset of physiologically normal puberty, and ends when an adult identity and behavior are accepted. The period of development roughly corresponds between the ages of 10 and 19 years” (Adolescent development, n.d.). This is a time in life when people are very susceptible to being injured because they are growing, their bodies are changing, and they are unfamiliar with their new bodies. One change during an adolescents growth period ligaments and tendons often grow faster than the bones mature causing avulsion fractures. When this happens, the adolescent is at a higher risk for injury (Prentice, 2016). In North America, sports are the leading cause of injuries that lead to medical attention and emergency room visits (Emery et al., 2005). 1.35 million children are seen in emergency rooms every year due to sports related injuries (Ferguson, 2013). We can help reduce the rate of injuries when athletes are young by teaching proper warm-up

components and techniques then more people will remain physically active throughout their lifetime, help to decrease obesity rates, help decrease the chance for re-injury, and increase their self-esteem.

### *Physical*

Adolescents go through hormonal and physical changes during this phase. Marshall and Tanner have identified five major areas that are developed during puberty. They include: 1) accelerated followed by decelerated bone growth, this can also be known as the ‘growth spurt’ that many adolescents go through. 2) Changes in fat tissue and muscle tissue. This could be a gain or reduction in either, or a movement of it from one place in the body to another. 3) Development of the respiratory and circulatory systems. With this development adolescents will see an increase in strength and endurance. 4) Maturation of secondary sexual characteristics and reproductive organs and 5) changes in the hormonal/endocrine systems. This change helps drive other changes (Adams & Berzonsky, 2006). All of these changes can have implications during sports because the body is changing so much and the athletes are not used to these changes. In this age group more fractures are seen due to new and fast bone growth and athletes are out longer with bone breaks because they take a longer time to heal than any other tissue (Houglum, 2010).

Preventing injuries in young athletes can also decrease the chance that the athlete will get injured again. There is a very high chance that the young athletes will reinjure themselves. According to the Youth Sports Safety Alliance, athletes with one or more previous injuries are two to three more likely to get injured compared to those without previous injuries (Kucera et al., 2005). Since these injuries happen while these athletes are growing there is a greater chance that healing process may be altered. In the end, this is going to lead to more pain and suffering by the

young athlete and even more financial burdens. Therefore, prevention of the first injury is as important as the prevention of on going injuries. Proper warm-ups with the athletes need to be done with those who have already been injured and those who have not.

Obesity is a huge epidemic in the United States and around the world and we need to do as much as possible to help decrease the rates of obesity. Obesity is defined as having excess body fat (Krebs, 2007). 78.6 million (34.9%) of Americans are obese as of 2014 (Ogden, 2014). 18% of children aged 6-11 were obese in 2012 and 21% of children aged 12-19 were obese (Ogden, 2014; National Center for Health Statistics). About 8% of adolescents drop out of sport activities each year due to injury. It appears that those who drop out are at a high risk for long-term morbidity and mortality rates (Emery et al., 2005). By keeping adolescents safe and physically active that we can help reduce the number of people who are suffering from obesity.

This is not the only way obesity can be prevented, but it is a good place to start. There is no simple solution for this problem, but rather there are many things, besides keeping adolescents active, that need to be combined to help this epidemic. If people from many different professions and backgrounds can work together, they will have a better chance of lowering obesity rates in the United States and around the world. According to the CDC, the solution for this epidemic needs to start with implementing healthy lifestyles early in a child's life and continuing this lifestyle forever ("Strategies," 2015). Not only do injuries have a huge affect on the health of the person who is injured, but they can also affect other aspects of the person's life.

### ***Psychological***

Exercise and body appearance help to increase self-esteem but a positive experience in the sport setting can also help. If an adolescent has a positive, injury free, experience when they are playing sports they are going to have an increase in self-esteem because they accomplished

something to be proud of. (Gruber, 1986; Yawkey, 1980). Psychologically injuries can be hard to overcome. If an athlete gets hurt doing something they love, even at a young age, it can be hard to regain everything they had before and this could have a dramatic effect on their self-esteem. If they are somehow ostracized from their teammates and the people they feel comfortable around, their self-esteem will suffer. The injured person is not left out on purpose, but when the person is injured it is just hard for them to do the same activities that the rest of the team is doing and have the same routine they are used to doing everyday (Readdy, 2015).

### *Financial*

Injuries can be a significant financial burden on a family. Medical costs for sports injury emergency department visits exceed \$935 million each year (Youth Sports Safety Alliance; Ferguson 2013). According to the Archives of Pediatrics and Adolescent Medicine in 2008 it cost approximately \$10,000 to \$15,000 for a lower limb injury that is treated in a physician's office or the emergency room. This estimate includes medical costs, work loss, pain and suffering, legal and liability costs (Brooks & McGuine, 2011). Injuries also have effects that can be detrimental to not only the athlete but the surrounding family members as well. According to Abernathy and MacAuley (2003) 32% of parents had to take time off of work so they could care for their children with sports injuries. Taking time off of work affects the financial side of the problem, which can be a huge drawback when the injuries are already expensive to start with. Since injury care is so expensive, it stands to reason many people would prefer prevention because it is a much cheaper alternative to injury. If young athletes are taught proper techniques for warm-up a substantial amount of money can be saved on injuries. Some prevention programs require no equipment, so there is no additional cost (Herman et al., 2012). This can be a great

advantage for programs or schools that have a tight budget and cannot afford additional equipment or staff members.

Between the physical, psychological, and financial burdens that come from injuries, it makes more sense to try and prevent injury rather than going through the burdens of an injury. Strategies and programs can be implemented in adolescent sports to help decrease the chance of injuries. Parents, coaches, trainers, physical education teachers, and athletes need to be willing to try these programs. Unfortunately, historically there has not been very much research focused on this topic. Fortunately though, more people are becoming aware of this and this field is definitely growing.

Overall, it does not matter why the injury was caused, but that injuries will cause significant disruption. Whether that disruption comes directly from missing the sport or they happen by missing school, they are going to greatly affect the athlete. They are also going to affect the family as a whole from time off work and/or arranging and paying for child care if the injury is significant enough (Abernethy & MacAuley, 2003).

### **Methods**

This literature review focused on females and males who participated in diverse sports as well as athletes who competed at different levels. Recreational and intermediate level sports were included, as well as physical education class activity. All athletes' risk getting injured while participating in their sport, therefore the focus was on all levels. Also, focusing on a diverse group of sports helped keep the results from becoming bias toward one sport. Since some sports have more contact and chances to get injured, there are sports that automatically have higher rates of injury regardless of the warm-up; therefore contact and non-contact sports were included to keep the results unbiased. After much research, it appears that males and females have

relatively similar rates of injury, however females are a little higher so both sexes were included in the literature review, again so the literature review was not bias toward one sex or the other. If there was a greater difference between the two, it may be better to focus on just one, but further research can help determine this.

Studying different levels of sport is important. When different levels of activity were studied in the Netherlands in their physical education classes, they found a reduced risk of injury in a low active group, but they did not find the same results for the high active group. They argued this group of children was important to study because the majority of a child's life is spent doing leisure activities, not necessarily the sport setting. They also argued that the risk of injury associated with such a wide variety of activities has not been researched enough. They studied 2210 children aged 10-12 years old and split them into different categories based on the amount of time per week they were active. They found a reduced rate of injury in the low active group when a school-based physical activity injury prevention program was used. However, they did not find a difference in the high active group when the program was in place. Within the low active group they found a 50% reduction in total injuries and more than a 50% reduction for sports injuries and leisure time injuries. Even though the findings in the study were not statistically significant, these results are important and show that more research is needed into different level of sports and physical activity (Collard, et al., 2010).

Currently, most time and effort is being put into the elite and professional level of athletes. This is unfortunate because that level of sport has the least amount of people competing in, but the most resources are focused there. Adolescents and recreational athletes are just starting sports and may not have a set routine that they are used to yet, and most people, even if they are not advanced athletes, are in this category. Even though the majority of resources are

focused towards the professional level, the focus should be the recreational and beginner levels (Readdy, 2015).

During the course of research there was a great amount of literature on anterior cruciate ligament (ACL) tears and concussions in youth sports because these are very common and serious injuries. Even though these are extremely common injuries in youth sports, unfortunately there are many more injuries that need research as well. Many different types of injuries are common at this age because this is when the body is growing. Many of the studies that were reviewed included injuries based on if there was time lost and medical attention needed. These are the studies that were included in this literature review. The injuries that were reported but required no medical attention or no time lost from the sport were not included in the studies that were reviewed.

The most common types of injuries that were included in the literature were minor soft tissue traumas, strains, sprains, bone breaks, and torn ligaments. This stands to reason because one third of all sports injuries are sprains. A sprain is when the ligament is partially or completely torn. This can be dangerous because ligaments are strong tissue that connect bone to bone and help stabilize joints. Strains are also common injuries in sports. A strain is when a muscle or tendon is partially or completely torn (Griffith & Friscia, 2004). This can also be damaging because our muscles allow us to move and tendons connect muscles to bones, so without muscles or tendons functioning properly, it is extremely hard to perform at a desired level. There are also other injuries such as broken bones, which account for 5 to 6 percent of sports injuries, along with concussions that account for more than 8 percent of the 1.35 million youth sports-related injuries reported to the emergency room (Ferguson, 2013). All of these

structures are extremely important for athletes, therefore if any of these structures are injured it becomes extremely difficult for the athlete to perform.

Many of these injuries require a substantial amount of time to heal before the athlete can return to competition. For instance, if someone tears just an anterior cruciate ligament (ACL), once they have surgery it takes about six months of intense rehab before they can return to sports. If other ligaments are involved it could potentially be longer (Evans, n.d.). Other common injuries such as an ankle sprains in adolescents can last from several days to several months depending on the severity. With the adolescent age group there is a tendency to be more conservative with the amount of time that they are held out of participation. (J. Knerr MS, ATC, LAT, personal communication, March 23, 2015). Also, many children who suffer concussions are encouraged to slowly return to daily activities with clearance from their physician. However, according to the CDC, full recover from a concussion can last much longer before the person is functioning back at their full mental capacity (“Recovery”, 2016). These are just a few examples of amounts of time lost for common injuries. The exact amount is going to change for every person and every injury.

## **Results**

After reviewing the literature on this topic it was found that proper dynamic warm-ups and injury prevention programs are helpful in preventing injuries in the adolescent age group. The different studies used techniques such as balance training programs, school based injury prevention programs, or proper neuromuscular warm-ups and education.

First of all, physiologically, a proper warm-up readies the body for physical activity. Dynamic warm-up activities dilate blood vessels which helps blood and oxygen flow easier through the body, getting more blood and oxygen to periphery tissues. They also get the heart

pumping which helps move blood better. Once the heart gets pumping and blood flowing, the body temperature rises allowing muscles, tendons, ligaments, and joints to become warm and more flexible, which makes them less susceptible to injury (Markarian, 2009; Prentice, 2016; Hewett et al., 1999)

To get the best results from a warm-up there are several characteristics that need to be included. For an adolescent age group, an adult should lead the warm-up. With an adult leading, the warm-up will be taken more serious and the proper movements will be done. Also, the correct amount of time will be focused to each area of stretching, strengthening, balance, sport-specific agility, and landing techniques. These components are necessary in a warm-up because they waken and prepare the neuromuscular system, which helps prevent injuries (Herman et al., 2012). With an adult leading the warm-up, the children are more likely to take it serious and understand that it is an important component in their practice and game routines. It would also be beneficial to have an adult lead the warm-up who has some experience with what they are teaching. Even if the adult has a short training in warm-up techniques, or they have years of experience, a little knowledge is going to greatly benefit the adolescents.

The specific strategies studied by Herman and colleagues (2012) were practical neuromuscular warm-up strategies that did not require any additional equipment, so no extra cost, and they were focused on the lower limbs. The first system was 'The 11+' which reduced injuries in young amateur female football players. This program consisted of exercises that focused on core stability, balance, dynamic stabilization, and eccentric hamstring strength, along with additional exercises that provided variation and progression. It included structured running exercises (Soligard et al., 2008). The Knee Injury Prevention Program (KIPP) was another strategy that worked with young female basketball and football players. It reduced injuries in the

lower limbs, and consisted of a neuromuscular training program focused to decrease the risk for ACL injuries in young female athletes (LaBella et al., 2011). The 'HarmoKnee' was found to reduce knee injuries. This program focused on increasing the awareness of injury risk, a structured warm-up program, and providing strengthening exercises aimed at producing less strain to the knee (Kiani, 2010). The Prevent injury and Enhance Performance (PEP) Program helped reduce ACL injuries and focused on neuromuscular control during an on field warm-up (Gilchrist et al., 2008). One last strategy was the Anterior Knee Pain Prevention Training Program (AKP PTP), which reduced anterior knee pain in female and male military recruits. This program consisted of four supervised strengthening and stretching exercises (Coppack et al., 2011). These five strategies are just programs that this study focused on but there are many others out there.

These specific and structured warm-ups should be completed before games and practice. More injuries happen in practice compared to games because so much more time is spent in practice than games. 62% of organized sport-related injuries happen during practice ("We work" n.d.). Even if teams practice 3 times a week for one hour each, that is three hours total for the week and they might play one hour and a half game. So, twice as much time is spent in practice than game time. Also, if we can teach the body these systems during every practice then the body will be much better prepared when it gets the same warm-up for the game, this is supported by muscle memory (Shusterman, 2011).

Muscle memory controls our habitual movements that we do on a regular basis that we may have learned intentionally or unintentionally. They are movements that we can do without having to think about it before we complete the movement. This can be extremely helpful for sport specific movements, but at the same time there is the possibility that they can be

detrimental to the athlete. If the movement is learned the improper way, it will become muscle memory incorrectly, therefore becoming detrimental to the athlete. This helps support why early intervention into adolescence is extremely important and why adults need to lead the warm-ups. If we can teach children correct dynamic stretching when they are young, their muscle memory will not become detrimental to their performance and it will help reduce their risk of injury (Shusterman, 2011).

Another very important component that needs to be included in the dynamic warm-up is sport similar movements. The body needs to get ready to do what it will be asked to do during drills or games (Markarian, 2009; Shusterman, 2011). If a volleyball player warms up without jumping, she/he is not going to ready the muscles that are going to be used to jump later in practice or competition. Just like a baseball or softball player should warm-up their arm before they practice or play. If a baseball player goes to throw a ball but never warmed up his arm, his arm is probably going to hurt and the throw is not going to go where the player wanted it to go.

For best results these warm-up programs need to be implemented into various aspects of an adolescent's life if we want to help keep as many of them active as we can. A study found that school physical education class based programs worked to help decrease injuries in their programs. These are important areas to target because recreational level sports have many injuries too (Collard et al., 2010). This study found that a low active group of students had a decrease in self-reported injuries when completing this school based physical activity injury prevention program (Collard et al., 2010). Even though this study did not show statistically significant differences between the control and testing group, there was still evidence of a decrease in injuries, which supports further research into this topic.

## Conclusion

Overall, injury prevention via proper dynamic warm-up is extremely important in adolescent physical activity. There are many burdens that come from injuries that make it hard for young people to remain active throughout their lives. We are in the middle of an obesity epidemic and this is one small step to take that will help keep this epidemic from getting worse than it already is. It can be physically, psychologically, and financially hard to overcome injuries at such a young age. A simple proper dynamic warm-up with the correct components and techniques can help save many adolescents and even adults from these burdens.

I agree with the findings in these articles but more research needs to be completed on this topic. Research that has been done has barely scratched the surface when it comes to adolescents and proper warm-up components and techniques. Specific further research that would be beneficial to the adolescent age group should focus on a number of things. Gender is a major detail that needs to be further researched. Males and females are very different especially during and around puberty. With more studies focusing on one sex or the other, we will be able to help prevent injuries that are more prominent in one sex or the other. Another factor that needs focus is the level of the sport or activity. There is an enormous difference between an elite athlete and a recreational athlete. However, many studies do not specify what level of athlete they are working with. Also the coach plays a huge role in youth sports and activities and their background should be studied. A volunteer coach who has never played the sport is going to teach young children completely different than a coach who has years of experience with those sport specific drills and movements. This may make an impact on injury risk.

Some of these factors may not have been studied due to some limitations that prevented research. Money has been a big limiting factor because there is not a lot of money invested into

youth sports. More money and resources are invested into professional sports and athletes (Readdy, 2015). Another limitation in most studies is the lack of time. Injuries take time to heal, but they also take time to happen. It can never be predicted when and where the athlete will get injured, therefore making it extremely difficult due to documentation, cost, and time to study one person for long enough to see if a specific program helped or did not help prevent an adolescent from getting injured. The previous literature also did not note what level the adolescents were participating at. One other limitation is that some of the studies are recall studies, so the athlete recalls what happened to him or her. This can skew results because the memory might not be accurate or unbiased. The athlete may have been too young to remember, or they report something different to make the injury sound more severe than it was or vice versa. It is also difficult to rely on records that were taken down by others because information could have easily been miscommunicated between the injured person and the recorder.

Overall, an adult led dynamic warm-up that consists of sport similar movements, neuromuscular training, stretching, strengthening, balance, and landing techniques should be completed before all games and practices. There are many programs available to choose from that include the required components. These programs will prepare the body for the specific sport or exercise. This program will help lower the risk of injuries in the adolescent age group. This can help eliminate many burdens that come from injuries and an inactive lifestyle. When the number of injuries in the adolescent age group decreases there will be more young kids who stay with sports and lead an active life. Research has been completed in this field, but much more research can still be completed to even better these necessary dynamic warm-ups.

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