

Characterization of Prepractice Injury Prevention Exercises of High School Athletic Teams

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Background: Static and dynamic exercises are performed before activity to decrease injury risk and increase performance. Although evidence supports using dynamic over static stretching and performing Fédération Internationale de Football Association (FIFA) 11+ as a dynamic prepractice routine, we do not know the frequency at which these exercises are utilized in high school populations.

Hypothesis: We hypothesize that there is a wide variety of preparticipation exercises performed by high school athletes, and that few high school teams perform FIFA 11+ as an injury prevention program in its entirety.

Study Design: Observational study.

Level of Evidence: Level 4.

Methods: High school prepractice routines were observed for 185 teams (football, soccer, basketball, and lacrosse) over 1 season. The percentages of team warm-up routines that included components of FIFA 11+ were calculated, and the chi-square test was used to compare sex, sport, and level of competition.

Results: Of a total 644 warm-up observations, 450 (69.9%) included only non-FIFA 11+ exercises, 56 (8.7%) included at least 1 FIFA 11+ exercise, and 38 (5.9%) included only jogging; 69 (10.6%) consisted only of sport-specific activities. The type of warm-up differed significantly between males and females ($P = 0.002$), sports ($P < 0.001$), and level of competition ($P < 0.001$). Static stretching and athletes stretching on their own were observed in 14% and 15% of all observations. No team performed the FIFA 11+ injury prevention routine in its entirety.

Conclusion: The type of warm-up differed by sex, sport, and level of competition. Static stretching was performed more frequently than anticipated, and an entire FIFA 11+ warm-up was never performed.

Clinical Relevance: We need to identify the exercises that decrease injury and increase performance and better inform the athletic population about the risks and benefits of static and dynamic warm-up programs.

Keywords: warm-up; injury prevention; FIFA 11+; static and dynamic stretch

Lower extremity injuries are common in high school sports and are associated with posttraumatic osteoarthritis and high costs. Fernandez et al⁷ estimate that 807,222 lower extremity injuries occur in high school athletes each year, or 1.3 injuries per 1000 athlete-exposures. Posttraumatic osteoarthritis can be observed in up to 70% of individuals 15 years after a serious sports-related lower extremity injury,^{16,20} and the

associated costs are high. For example, the estimated cost of providing health care for athletic injuries in North Carolina was \$9.9 million in medical costs, \$44.7 million in capital costs, and \$144.6 million in comprehensive costs.¹⁴

Warm-up exercises are performed before engaging in physical activity to decrease injury risk and increase athletic performance.^{4,6,31} The importance of performing preactivity

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warm-up exercises lies in the ability to increase muscle temperature and the muscle's ability to stretch, as well as to activate other physiological responses.^{4,6,11,24,31} The need for a preactivity warm-up has been established; however, the particular components of warm-up protocols have continued to change over time.

Controversy exists in determining whether dynamic or static stretching exercises should be performed during a preathletic event. Recently, research has supported the use of dynamic over static stretching because of the benefits of increased muscular performance after dynamic stretching.^{1,2,9,12,15,19,32} Herman and Smith¹² found that a 4-week dynamic warm-up intervention with collegiate athletes showed sustained improvements in strength, power, muscular endurance, and agility performance, while none of these improvements was observed in the static stretching warm-up group.¹² Little and Williams¹⁵ and Amiri-Khorasani and Sotoodeh² also suggest that for athletes engaging in high-speed performance, such as soccer players, a dynamic warm-up might be a more effective form of preparation because of faster sprinting times and increased agility after dynamic stretching. The major drawback to dynamic stretching is that it may not increase muscle extensibility.²² On the other hand, the major benefit of static stretching is that it increases extensibility, especially in the hamstring muscles.²² Increasing muscle extensibility benefits athletes in sports requiring more joint range of motion. However, the detrimental effects of static stretching on performance have also been investigated. Static stretching has a negative impact on sprint performance²⁵ and decreases explosive performance for up to 24 hours poststretching.⁸ Although controversy has existed in the past, there is an ongoing shift in the warm-up practices of athletes to move away from static stretching toward a more dynamic program.^{1,2}

A review of warm-up practices suggests that there is a need for coaches to realign their preactivity warm-up with more current research guidelines.¹³ Currently, research supports that the Fédération Internationale de Football Association (FIFA) 11+ injury prevention program is an appropriate prepractice/pregame warm-up and has proven effective in injury prevention^{3,5,17,23,26-29} and increasing athletic performance in mostly soccer athletes.²⁹ The FIFA 11+ program is a dynamic warm-up program divided into 3 parts consisting of running, strengthening, and sprinting drills that takes approximately 15 minutes to perform.²⁷ A study of female youth soccer players in Norway found that players who performed the FIFA 11+ program throughout the season experienced a 68% reduction in risk of injuries compared with control subjects.²⁷ Additionally, increased compliance with the FIFA 11+ program increased the effectiveness of the program.²⁸ While the effectiveness of the FIFA 11+ program has been established in both male and female soccer players, the application of the program to other sports is only beginning to be investigated. Longo et al¹⁷ examined the effects of the FIFA 11+ program in male basketball players and demonstrated that athletes in the FIFA 11+ intervention group had significantly lower injury rates overall, and in particular, reduced injury rates of the lower extremity.

Very little is known about the actual exercises used to warm up and prevent injuries in high school athletes, and less is known about how the exercise routines vary by sex, sport, and level of competition. The purpose of this study was to characterize the warm-up exercises performed at 14 high schools (185 teams) over the year and to determine whether the exercise type (running, dynamic mobility training, dynamic stretching, static stretching, strengthening, plyometric training, agility/balance training, and performing either sport-specific or FIFA 11+ exercises) varied by sex, sport, and level of competition. Finally, this observational study was designed to inform a current randomized controlled trial to determine whether using FIFA 11+ is effective at decreasing injury in high school athletic programs.

METHODS

The internal review board gave permission to observe 14 local high schools during the 2015-2016 academic school year. The schools were selected based on school location (50-mile radius), sports offered, and presence of a certified athletic trainer on campus. There were 185 total teams (at the freshman, junior varsity, and varsity levels) enrolled, and these involved 4 boys' sports (20 football, 32 soccer, 34 basketball, and 24 lacrosse teams) and 3 girls' sports (27 soccer, 27 basketball, and 21 lacrosse teams). No instructions were given to the teams regarding the injury prevention routine that they performed. The FIFA 11+ exercises were not described or taught to any of the school teams or coaches. Therefore, the teams performed their usual prepractice injury prevention routine.

The research team "observers" were trained on specific warm-up exercises and FIFA 11+ exercises by an "expert" certified athletic trainer who previously implemented the FIFA 11+ injury prevention program for a National Collegiate Athletic Association (NCAA) Division 1 soccer team. The observers were trained to record individual exercises on an outcome instrument (see the Appendix, available in the online version of this article). The outcome instrument was divided into categories that described the type of activity performed, including running, dynamic mobility training, dynamic stretching, static stretching, strengthening, plyometric training, agility/balance training, and sport-specific and FIFA 11+ exercising components. The educational backgrounds of the observers included medical students, athletic training students, and physical therapy students. The lowest intraclass correlation coefficient (ICC) between observers was 0.69, and the highest was 0.94. The lowest ICC within observers was 0.81, and the highest was 1.00. The observers made 4 observations for each team over the course of the season, with 2 of the team observations being performed by the "expert" athletic trainer.

Statistical Analysis

The percentages of warm-ups that included specific exercise components of FIFA 11+ were calculated, and chi-square tests were used to compare differences between sexes, level of play, and sport played.

RESULTS

There were 740 planned observations of injury prevention prepractice exercise routines, and a total of 644 were completed. Ninety-six teams were observed 3 instead of 4 times because of a shortened season (freshman and junior varsity schedules), canceled practice, or field change on observation day. Of the 644 warm-up observations, 56 (8.7%) included at least 1 FIFA 11+ exercise, 450 (69.9%) included only non-FIFA 11+ exercises, 38 (5.9%) included only jogging, and 68 (10.6%) consisted only of sport-specific activities. For 32 (5.0%) observations, no warm-up exercise was performed before starting practice (Table 1). The type of warm-up differed significantly between males and females ($P = 0.002$), sports ($P < 0.001$), and levels of competition ($P < 0.001$). More of the warm-ups for females (14.0%) than males (4.8%) included at least 1 FIFA 11+ exercise component (Table 1). FIFA 11+ exercises were performed most often in soccer warm-ups (17.3%) and least often in basketball warm-ups (2.2%). Inclusion of FIFA 11+ exercises into warm-ups also increased with increasing level of competition, from 1.4% of warm-ups for freshman teams to 12.7% of those for varsity teams. Nearly one-third (29.6%) of basketball warm-ups consisted only of sport-specific exercises (Table 1).

All 56 warm-ups that incorporated FIFA 11+ exercises into the practice routine included at least 1 of the exercises in part 1 (running), but only 17 (30.4%) included all 6 of these exercises. Ten (17.2%) warm-ups included at least 1 part-2 (strengthening) exercise, and 14 (24.1%) included at least 1 part-3 (sprinting) exercise. Only 3 (5.4%) warm-ups included exercises from all 3 parts of the FIFA 11+ program, while 35 (62.5%) included only part 1 running exercises. The 3 warm-ups that included exercises from all 3 parts of the FIFA 11+ program were from the same varsity football team. No team performed the entire FIFA 11+ warm up exercise program.

All but 1 of the warm-ups that incorporated some FIFA 11+ components also included non-FIFA 11+ exercises (Table 2). Non-FIFA 11+ running exercises were performed less often than in warm-ups without a FIFA 11+ component (66.1% vs 90.7%), as would be expected because the FIFA 11+ running exercises were used instead. Inclusion of non-FIFA 11+ dynamic mobility, dynamic stretching, static stretching, strength, and plyometric exercises did not differ significantly between warm-ups with and without FIFA 11+ exercises (Table 2). However, warm-ups using some component of the FIFA 11+ program were significantly less likely to include stretching on one's own (3.6% vs 20.2%) and sport-specific exercises (3.6% vs 28%). However, they were significantly more likely to include agility and balance exercises (21.4% vs 7.3%). Static stretching and stretching on one's own (which included individuals performing static stretching) were observed in 7 of 56 (12.5%) warm-ups using FIFA 11+, in 175 of 450 (38.9%) warm-ups not using any FIFA 11+ exercises, and in 182 of 644 (28.2%) total warm-ups.

Based on data from warm-ups that included either FIFA 11+ or non-FIFA 11+ exercises (excluding warm-ups consisting only of jogging or sport-specific activities), the types of non-FIFA 11+ exercises performed in warm-ups for male and female teams

were generally similar. However, significantly fewer of the male than female warm-ups included dynamic stretching (82.5% vs 89.1%, $P = 0.038$) and significantly more included strength exercises (20.3% vs 10.5%, $P = 0.003$). Level of competition was significantly associated with the use of dynamic mobility ($P = 0.005$), dynamic stretching ($P < 0.001$), static stretching ($P = 0.031$), and agility or balance ($P = 0.027$) exercises, with an increase across freshman, junior varsity, and varsity teams. Sport had the largest influence on the type of non-FIFA 11+ exercises performed during warm-ups (Table 3). Only use of plyometric exercise ($P = 0.053$) and agility or balance exercises ($P = 0.266$) did not differ significantly across the 4 sports in which warm-ups were observed. The types of exercises performed in soccer and lacrosse warm-ups were generally similar, although more of the latter included sport-specific exercises. Basketball warm-ups were less likely to include running and dynamic stretching exercises and more likely to include stretching on one's own and sport-specific exercises. Football warm-ups were more likely to include static stretching and strength exercises.

DISCUSSION

We fully characterized 644 warm-up routines of 185 high school athletic teams, and a wide variety of exercises were observed. We observed that exercise type varied significantly by sex, sport, and level of competition, and that sport had the greatest impact. Lacrosse warm-ups were more likely to include sport-specific activity; basketball less likely to include dynamic stretching, running, or using any FIFA 11+ exercise; and football more likely to include static stretching and strengthening. More female than male, soccer than basketball, and varsity than junior varsity and freshman teams performed FIFA 11+ exercises in their warm-up routines. Teams that used at least 1 FIFA 11+ exercise were less likely to use stretching on one's own or sport-specific drills to warm up their athletes and more likely to add agility and balance exercises to the warm-up.

Characterizing the types of exercises designed to decrease injury performed by high school athletic teams is critical to the design and implementation of a successful injury prevention program and to the evaluation of its component exercises. To our knowledge, the typical exercises included in high school teams' warm-up injury prevention programs have not been described in the literature. We now know that most teams that were studied perform a unique set of exercises using a variety of running, dynamic movement, and dynamic stretching exercises, and no school or team has adopted the FIFA 11+ warm-up program in its entirety. However, a surprising number of the teams (11%) either chose not to warm up or simply jog to prepare for practice.

Much debate has been centered on whether to use static or dynamic stretching as a preperformance activity.^{1,2,8,10,12,15,19,21,25,32} Presently, it is clear that dynamic stretching increases performance^{1,2,10,12,15,19,32} while static stretching decreases performance, muscle strength, and reaction time.^{8,19,25} Even though the evidence for dynamic over static stretching is significant, static stretching was performed a significant amount

Table 1. Types of warm-up performed by sex, sport, and competition level^a

Warm-up Type	Sex		Sport				Level of Competition			
	All Warm-ups (n = 644)	Male (n = 372)	Female (n = 272)	Soccer (n = 220)	Football (n = 64)	Basketball (n = 230)	Lacrosse (n = 130)	Freshman (n = 74)	Junior Varsity (n = 231)	Varsity (n = 339)
FIFA 11+ exercise included	8.7	4.8	14.0	17.3	7.8	2.2	6.2	1.4	5.2	12.7
Non-FIFA 11+ exercises only	69.9	72.0	66.9	72.3	76.6	57.0	85.4	52.7	71.9	72.3
Jogging only	5.9	6.5	5.1	3.2	15.6	7.4	3.1	13.5	6.1	4.1
Sport-specific exercises only	10.6	11.6	9.2	0.0	0.0	29.6	0.0	24.3	12.6	6.2
No warm-up performed	5.0	5.1	4.8	7.3	0.0	3.9	5.4	8.1	4.3	4.7

FIFA, Fédération Internationale de Football Association.

^aAll values are in percentages.

Table 2. Observations of warm-up exercise components performed by teams using FIFA 11+ and non-FIFA 11+ exercises

Warm-up Exercise Component	Warm-ups Using Some FIFA 11+ (n = 56)		Non-FIFA 11+ Warm-ups (n = 450)		P Value
	n	%	n	%	
Running	37	66.1	408	90.7	<0.001
Dynamic mobility	47	83.9	410	91.1	0.087
Dynamic stretch	46	82.1	386	85.8	0.468
Static stretch	5	8.9	84	18.7	0.071
Stretch on own	2	3.6	91	20.2	0.002
Strength	8	14.3	73	16.2	0.709
Plyometric exercise	0	0.0	24	5.3	0.077
Agility/balance exercise	12	21.4	33	7.3	<0.001
Sport-specific exercises/skills practice	2	3.6	126	28.0	<0.001

FIFA, Fédération Internationale de Football Association.

Table 3. Non-FIFA 11+ exercise components performed by sport^a

Warm-up Exercise Component	Soccer	Football	Basketball	Lacrosse	P Value
Running	89.8	90.7	77.2	95.8	<0.001
Dynamic mobility	92.4	81.5	85.3	96.6	0.002
Dynamic stretch	90.9	88.9	72.1	89.9	<0.001
Static stretch	16.2	44.4	14.7	10.9	<0.001
Stretch on own	18.8	0.0	27.2	16.0	<0.001
Strength	8.6	63.0	11.8	11.8	<0.001
Plyometric exercise	3.0	0.0	8.1	5.9	0.054
Agility/balance exercise	7.1	13.0	11.8	6.7	0.266
Sport-specific exercises/skills practice	6.1	1.9	60.3	27.7	<0.001

FIFA, Fédération Internationale de Football Association.

^aAll values are in percentages.

of the time. Surprisingly, static stretching was observed in 12.5% of warm-ups using FIFA 11+, in 38.9% warm-ups not using any FIFA 11+ exercises, and 28.2% of total warm-up programs.

Although, FIFA 11+ was designed to be used as a prepractice warm-up program, with the benefit of increasing performance and decreasing injury,^{3,5,13,17,23,26,27,29} no team in this investigation, including male and female high school soccer teams, chose to use the program in its entirety. Only 9% of the teams used some of the FIFA 11+ warm-up exercises. Of the

teams performing FIFA 11+ exercises, only 17% performed at least 1 of the strengthening exercises.

We observed that female teams performed FIFA 11+ exercises more often than male teams (14% vs 5%, $P < 0.05$). Our finding was similar to that from a study by Martinez et al,¹⁸ which found that female athletes are willing to perform injury prevention programs if they perceive a potential to decrease injury or anterior cruciate ligament injury. However, the authors surveyed only female athletes, while our observational study included

both sexes and we did not present any data to the individual athletes about the benefits of injury prevention.

The strengths of this research lie in the large number of teams, multiple sports, and multiple levels of play of both sexes at 14 high schools. No FIFA 11+ training was provided to any coach or high school before the study. This provided a good population to characterize the actual exercises performed by the athletic teams. The weaknesses of this study are inherent in the study design. This work was observational and therefore cannot address the relative efficacy of any of the warm-up exercises to improve athletic performance or prevent injury. Also, the results may not be generalizable to high schools located in other regions of the United States as this study was performed in a rural setting in a sparsely populated state with a predominantly white population. Future studies from our group will look at implementing the FIFA 11+ program in both high school and middle school environments.

Our recommendation from this observational study is that we need to better educate high school coaches about the advantages of performing a dynamic preexercise workout and the optimal timing of static stretching. Additionally, this study serves as a foundation to begin to determine what exercises performed by athletes might be responsible for decreasing injury and increasing performance. Future study designs will need to take into consideration that coaches may be unwilling to change their routines. Additionally, there might be a perceived lack of time to fully incorporate dynamic injury prevention programs into team warm-up programs.³⁰

CONCLUSION

Exercise type performed varied by sex, sport, and level of competition, with sport having the greatest impact. Although it is well documented that FIFA 11+ can be substituted for a traditional warm-up program and has the benefits of decreasing injury and increasing performance, no local high school team has adopted the FIFA 11+ program as their warm-up routine. Surprisingly, despite evidence of the detrimental effects of prepractice static stretching, nearly 30% of the teams' warm-up routines included static stretching prior to practice.

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