

Compliance and Fidelity With an Injury Prevention Exercise Program in High School Athletics

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Background: Use of injury prevention programs (IPPs) by high school athletes has increased but their success in reducing injury depends on program compliance and fidelity of exercise performance.

Hypothesis: Compliance with the 11+ IPP and exercise performance fidelity by high school athletic teams depend on sex, sport, and level of play.

Study Design: Secondary analyses of data from a randomized controlled trial (RCT).

Level of Evidence: Level 2.

Methods: The 11+ IPP was implemented by 100 male and female high school athletic teams (American football, soccer, basketball, and lacrosse). Team compliance and fidelity with the program were evaluated by direct observation of warm-up routines and a weekly online survey completed by coaches. Differences in compliance and fidelity due to sport, sex, and level of play were assessed by analysis of variance.

Results: Coaches reported that their teams performed the full IPP an average of 1.45 times per week, and 28% of observed warm-ups included all exercises in the IPP. Compliance differed by sport but not by level of play or the athletes' sex. At the end of the season, cueing was observed 19% of the time and differed by sport. Good technique was observed 66% of the time and varied by level of play.

Conclusion: Team compliance with the IPP varied by sport and was below the recommended number of sessions per week needed to reduce injury. Removal of implementation barriers and improved support from coaches are needed at all levels of play for IPPs to be effective.

Clinical Relevance: Clinical and sports practitioners intending to implement an IPP at the high school level should anticipate and address barriers that affect program compliance and fidelity of exercise performance. Frequent follow-up and instruction may be necessary for successful adoption of the IPP.

Keywords: injury prevention; sports; exercises; compliance; fidelity

In the United States, the number of high school students participating in sport has doubled since the 1971 to 1972 academic year to include nearly 8 million participants during the 2016-2017 academic year.¹¹ During the 2015 to 2016 academic year, there were an estimated 1.2 million injuries among US high school athletes that resulted in an absence of participation for more than 1 day.²⁶ While injuries will always

occur in sports, coaches, athletes, and medical professionals recognize the need to minimize the risk of injury by implementing valid, feasible injury prevention strategies.

For several decades, researchers have been developing effective sport injury prevention programs (IPPs).²¹ Despite the strong public advocacy and education centered on IPPs, compliance with and overall uptake of these programs remain

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relatively low. This is especially surprising given that adequate compliance with IPPs has been shown to reduce injury rates among athletes.^{2,3,12,16,19,22,25}

Compliance and fidelity with IPPs are important factors that determine the success of the program. Compliance indicates both the proportion of exercises completed in relation to the total possible per session as well as the frequency with which the IPP is utilized over the course of fixed time interval such as a sports season or during the off season in preparation for participation in sport. Exercise fidelity is reflected by the proportion of completed exercises that were executed using the proper technique.¹³ Compliance can be measured at the team or individual level. Team compliance is driven by the motivation of the head coach and their interest in requiring their team to perform the IPP and the extent to which an intervention has been accepted by the team as a whole. Compliance of the individual athletes reflects their willingness to participate in the IPP.²⁰ When an athlete does not perform individual exercises as they are prescribed, the lack of fidelity may decrease the benefits of the IPP.⁷ Thus, evaluation of compliance and fidelity provides insight into why a program may have been ineffective at reducing injury rates. At the current point in time, little is known about compliance and fidelity associated with participation in IPPs at the high school level, and no studies have examined how compliance and fidelity vary with sport, an athletes' sex, and their level of play.

The primary aims of this study were to assess the compliance of high school sports teams with an intervention designed to reduce sport-related injuries, the 11+ IPP and to assess the fidelity with which the exercises that were performed. An additional aim was to determine how compliance and fidelity are influenced by an athletes' sex, sport, and level of play. Our goal is to determine the feasibility of implementing the 11+ IPP for a variety of high school sport teams.

METHODS

Study Design

This study used compliance and fidelity data acquired from a randomized controlled trial (RCT) to assess the efficacy of the 11+ IPP for use by high school level athletes (aged 14-18 years). The full details of the RCT have been described in a previous publication.¹⁸ Fourteen high schools enrolled in the RCT were randomly assigned to either the intervention group (n = 7) or control group (n = 7). Teams at the control schools did not receive an intervention; therefore, only data from the intervention schools were used in the current study.

Participants

Both boys and girls sports teams at the 7 schools receiving the intervention were included in the study. American football, soccer, basketball, and lacrosse teams of all levels (freshmen, junior varsity, and varsity) were studied, for a total of 100 teams (58 men, 42 women) during the 2016 to 2017 academic year.

Intervention Program

The 11+ IPP previously referred to as the FIFA 11+, is an IPP designed to replace the usual prepractice warm-up among soccer teams. The program consists of 3 parts with 15 exercises in total. Parts 1 and 3 encompass dynamic mobility, running, and agility exercises. Part 2 includes strengthening, balance, and plyometric exercises. Part 2 exercises have 3 levels of increasing difficulty for each exercise. This allows for progression over the course of the season.^{4,15}

Program Implementation

Teams at schools in the intervention group received several types of instruction on use of the 11+ IPP, including a coaching seminar, team training sessions, instructional placards, a training manual, and access to resources online (https://www.fifamedicalnetwork.com/wp-content/uploads/cdn/11plus_workbook_e.pdf). Research personnel performed the instructional sessions with coaches and teams and remained available to answer questions or provide further guidance on request. Teams were encouraged to do the full program at least twice per week and parts 1 and 3 on game days. Part 2 of the program consists primarily of strengthening exercises and was omitted on days of competition to avoid muscle fatigue. Dosage recommendations were taken from the FIFA Medical Assessment and Research Centre (F-MARC).⁴ The IPP was first implemented during preseason training and lasted the length of the 3 respective sports' seasons.

Compliance and Fidelity Assessment

Compliance and fidelity were measured at the team level, rather than the individual level. Individual assessment of compliance and fidelity was not feasible because of the large size of the RCT and the difficulty associated with obtaining parental consent and assent to obtain identifiable data from every athlete before the season started. Compliance was measured both as the number of times the 11+ IPP was performed weekly, as well as the proportion of observed warm-ups that included all 11+ exercises. Self-reported frequency of performance was obtained by a weekly survey of coaches, which asked how many times their team completed the full 11+ IPP (parts 1-3) and partial IPP (parts 1 and 3) per week. The overall proportion of warm-ups that included the full 11+ IPP was estimated from direct observation of warm-ups by investigators and trained staff. Observers were encouraged to be out of sight while watching the warm-ups, but this was not always possible depending on the location of the practice. Each team was observed 2 to 6 times throughout the sport season using an assessment developed by the investigators to document the performance of all 15 exercises of the IPP. A test-retest reliability study was conducted to ensure the assessment tool could be used consistently among multiple observers and good reliability was observed for a majority of the exercises.¹⁷ To evaluate team performance, an exercise was recorded as having been performed if it was done by more than half of the athletes on a team.

Fidelity of performance was also assessed by observations recorded on the assessment tool at each visit, indicating whether cueing was used when an 11+ exercise was performed and how well the exercise was performed. If half or greater of the athletes on a team performed the exercise correctly, the team was considered to have used good technique, otherwise the exercise was noted as being done incorrectly. All exercise components of the IPP were evaluated for technique and cueing. Observers were trained by research personnel with expertise in the 11+ IPP and attended multiple guided observation sessions before using the assessment tool independently. To minimize subjectivity when assessing exercise technique, observers were instructed to reference the 11+ manual, as it explicitly defines both correct and incorrect body position for each exercise. For example, when performing the “squats with toe raise” exercise, it is important that knees, hips, and ankles remain in alignment when viewed from the front of the athletes. If the knees buckle inward, the observer marks the exercise as being performed incorrectly. The observational checklist is available in the appendix (available in the online version of this article).

Research personnel monitored team compliance on a weekly basis. Teams with low compliance were contacted and follow-up instruction was encouraged, but not required. Research personnel provided feedback to teams on program execution, when it was appropriate to do so, after observation sessions.

Statistical Analysis

The average number of times per week that each team performed the full 11+ IPP, or performed parts 1 and 3, were determined from the coaches' weekly reports. Differences due to sport, sex, and level of play were assessed by analysis of variance (ANOVA). The number of exercises performed in each of the 3 parts of the 11+ IPP was determined by each team's last observed warm-up. These exercise counts were used to create 4 measures of compliance: performance of all exercises in all 3 program parts, at least half of the exercises in each of the 3 sections, all exercises in parts 1 and 3, and at least half the exercises in each of parts 1 and 3. Chi-square tests were used to compare the percentage of teams meeting each of these respective criteria in relation to sport, sex, and level of play. Data from the last observed warm-up were also used to compute the percentage of exercises the team performed that used cueing and good technique. These percentages were analyzed by ANOVA to assess the effects of sport, sex, and level of play. For all analyses P values <0.05 were considered statistically significant.

RESULTS

Compliance

Based on coaches' weekly reports, teams performed the full 11+ IPP an average of 1.41 times per week, and there were no

significant differences in the frequency of performance between male and female teams (Table 1). There were significant differences in how often teams did the full 11+ IPP between sports ($P < 0.001$), but these differences were not consistent across male and female teams. For boys, the full 11+ IPP was done more often by football and soccer teams than basketball and lacrosse teams ($P < 0.05$), while for girls there were no significant differences between any of the sports studied. Coaches' weekly reports indicated that their teams performed only parts 1 and 3 of the 11+ IPP an average of 2.23 times per week, with similar frequency for both boys and girls teams. There were differences between sports ($P < 0.001$) but these did not vary with sex. Across both sexes, 11+ parts 1 and 3 were done significantly more times per week by athletes participating on soccer teams than those taking part in basketball ($P < 0.05$). The frequencies of performing the full 11+ IPP and only parts 1 and 3 did not differ significantly between freshman, junior varsity, and varsity teams.

A total of 432 warm-ups were observed by research personal, who classified 121 (28.0%) as having included all exercises in all 3 parts of the 11+ IPP. The time required to complete the 11+ IPP ranged from 12 to 39 minutes, with an average duration of 23.8 minutes. Only 8 of the 100 teams in the study performed the full 11+ IPP at all observed warm-ups. These included 1 football team, 3 boys' soccer teams, 2 girls' lacrosse teams, and 2 girls' basketball teams. Many of the observed warm-ups included 1 or 2 parts of the 11+ IPP. There were 330 (76.4%) warm-ups in which all six 11+ part 1 exercises were observed and they took an average of 6.8 minutes to complete (range, 3.0-13.5 minutes). All 6 part 2 exercises were performed in 151 (35.0%) of the observed warm-ups and they took an average of 13.1 minutes to complete (range, 5.0-22.0 minutes). The 3 exercises in part 3 were performed in 286 (66.2%) of the warm-ups and they were completed in an average of 2.5 minutes (range, 1.0-9.0 minutes).

A summary of the numbers of program sections and exercises performed during the last warm-up observed for each team are shown in Table 2. A total of 22 teams (22%) performed all exercises in each of the 3 parts of the 11+ IPP and were consistent with self-reported compliance; there were substantial variations across sports. More soccer teams (40.0%) performed all the exercises compared with football (18.2%), basketball (11.8%), and lacrosse (13.0%). The teams performing all exercises did not differ significantly by an athletes' sex or level of play. A larger number of teams (33.0%) performed at least half of the exercises in each of the 3 parts of the IPP and again there were significant differences between sports ($P < 0.001$), with more football and soccer teams than basketball and lacrosse teams performing at least half the exercises. When only the exercises in parts 1 and 3 of the 11+ IPP were considered, 58.0% of teams performed all the exercises in both parts and 73.0% of teams performed at least half the exercises in each part. The percent of teams performing exercises in parts 1 and 3 of the IPP did not differ significantly by sport, sex, or level of play.

Table 1. Self-reported number of times the 11+ IPP was performed each week

	No. of Teams	Parts 1, 2, and 3		Parts 1 and 3 only	
		Mean	SD	Mean	SD
Football	11	2.58 ^a	0.72	2.00	1.18
Soccer	32	1.95	1.09	2.79 ^b	1.09
Boys	17	2.22 ^a	1.05	2.78	0.96
Girls	15	1.65	1.09	2.80	1.25
Basketball	34	1.02	0.79	1.81	1.18
Boys	19	0.76	0.60	1.74	1.22
Girls	15	1.34	0.91	1.90	1.15
Lacrosse	23	0.67	0.85	2.44	1.50
Boys	11	0.58	0.89	2.56	1.39
Girls	12	0.75	0.84	2.34	1.66
All sports	100	1.41	1.10	2.29	1.28
Boys	58	1.50	1.17	2.25	1.23
Girls	42	1.28	1.00	2.34	1.36

^aSignificantly higher ($P < 0.05$) than boys' basketball and lacrosse teams.

^bSignificantly higher ($P < 0.05$) than basketball across both boys' and girls' teams.

Fidelity

Based on the exercises performed by each team, cueing was observed being used for 19% of the exercises and it was used significantly more often by football and soccer teams than basketball and lacrosse teams (Table 3). There were no significant differences in the use of cueing between boys and girls teams or between freshman, junior varsity, and varsity teams. Overall, 66% of exercises were assessed as performed with good technique and this did not differ between sports or between girls and boys teams. However, a significantly greater proportion of the exercises performed by varsity teams (73%) had good technique, compared with junior varsity teams (67%) and freshman teams (58%).

DISCUSSION

The primary purpose of our study was to characterize the compliance of the 11+ IPP among high school sports teams and to determine if compliance varied by sex, sport, and level of play in an effort to demonstrate the feasibility of implementing the 11+ IPP among athletes participating in high school sports. An additional aim was to assess the fidelity with which the exercises were performed. On assessment of these factors, we found that compliance differed across sports, but not with sex or level of play.

Compliance

Team compliance, averaging 1.41 full 11+ sessions per week over the course of a season, is consistent with existing literature detailing poor compliance with the program.²⁵ A meta-analysis of RCTs utilizing the FIFA 11 and 11+ programs found only 13% of soccer teams achieved the benchmark of completing 2 team sessions per week.²⁵ The current study provided teams with ample resources and opportunities to achieve optimal implementation, yet uptake of the program remained low. Low compliance may be due to a decline in coaches' interest and enthusiasm over the course of the season, season pressures, time constraints associated with practice, and environmental constraints.

While it is clear that head coaches are critical to the implementation and compliance with an IPP,³ a previous study revealed that compliance was higher among teams that participated in a 2.5-hour educational workshop before the start of their sports season.²³ After the workshop, coach-led delivery of an IPP was equally successful with or without on-field involvement from a physiotherapist. For the current study, the coaches were encouraged to attend 11+ education sessions; however, coach attendance was variable across the academic year. While previous studies had coaches learn and deliver the IPP to their teams on their own,^{5,19,23,24} this study used qualified research personnel to disseminate the original

Table 2. 11+ exercises performed at the last observed warm-up

Exercises Performed in Each Part	Total Teams	Parts 1, 2, and 3				Parts 1 and 3			
		All		Half or More		All		Half or More	
		n	%	n	%	n	%	n	%
All teams	100	22	22.0	33	33.0	58	58.0	73	73.0
Football	11	2	18.2	7	63.6 ^b	5	45.5	9	81.8
Soccer	32	13	40.6 ^a	17	53.1 ^b	20	62.5	26	81.3
Basketball	34	4	11.8	5	14.7	22	64.5	23	67.6
Lacrosse	23	3	13.0	4	17.4	11	47.8	15	65.2
Boys	58	13	22.0	20	34.5	36	62.1	44	75.9
Girls	42	9	21.4	13	31.0	22	52.4	29	69.0
Freshman	13	4	30.8	4	30.8	8	61.5	8	61.5
Junior varsity	41	8	19.5	12	29.3	23	56.1	30	73.2
Varsity	46	10	21.7	17	37.0	27	58.7	35	76.1

^aSignificantly higher ($P < 0.05$) than football, basketball, and lacrosse.

^bSignificantly higher ($P < 0.05$) than basketball and lacrosse.

Table 3. Proportion of performed exercises that used cueing and good technique

	Cueing		Good Technique	
	Mean	SD	Mean	SD
All teams	0.19	0.28	0.66	0.29
Football	0.36 ^a	0.34	0.70	0.34
Soccer	0.30 ^a	0.34	0.74	0.24
Basketball	0.10	0.18	0.55	0.27
Lacrosse	0.04	0.10	0.67	0.30
Boys	0.22	0.31	0.64	0.30
Girls	0.14	0.24	0.68	0.26
Freshman	0.30	0.32	0.58	0.28
Junior varsity	0.26	0.32	0.67	0.27
Varsity	0.20	0.29	0.73 ^b	0.28

^aSignificantly higher ($P < 0.05$) than basketball and lacrosse teams.

^bSignificantly higher ($P < 0.05$) than freshman and junior varsity teams.

instruction of the IPP. This form of implementation was used, because many coaches were unfamiliar with the IPP and we wanted to enhance and control the consistency of

implementation across all teams with the same approach. The use of trained research personnel to facilitate the IPP was not maintained as the season progressed, with the expectation that

coaches would initiate and cue the exercises. However, research personnel remained available for continued instruction and guidance with the IPP on request.

Compliance with the IPP is dependent on resources like field access and scheduling. Football and soccer had higher compliance rates than did basketball and lacrosse teams. This could be attributed to schedule restrictions: High school football typically plays 1 game per week allowing for more opportunities to perform the full IPP during practice. Additionally, soccer and football teams (both of which exhibited greater compliance) did not have to compete for practice space, which likely allowed for more time to be dedicated to executing the complete 11+ IPP. Basketball teams, on the other hand, had limited court time and lacrosse teams did not practice outside for the first part of their season unless turf was accessible due to field conditions. Thus, it seems that compliance may be highly dependent on resource accessibility.

Fidelity

Soccer teams performed 11+ IPP more than other teams in the study. The 11+ IPP was originally designed and intended for use among soccer players. It is likely that soccer athletes and coaches were exposed to 11+ exercises on their club teams and therefore performed a greater proportion of the 11+ exercises than football, basketball, and lacrosse teams. Additionally, the consistently lower fidelity among nonsoccer teams suggests that teams may have felt it was not relevant to their sport. Soligard et al²⁰ found that if a coach felt the IPP did not include enough soccer-specific exercises, the probability of low compliance increased by 81%. These findings may explain why nonsoccer teams exhibited lower fidelity. It is unlikely that team motivation to perform the IPP is the only implementation barrier; other factors such as relevance, perceived difficulty, and overall content of the intervention in relation to the sport the athlete participates in should also be considered.²⁰

Part 2 exercises were only performed 34.9% of the time. This percentage may be an overestimate, because it is possible that the presence of an observer influenced the team's behavior and encourage them to perform the exercises on the day they were monitored. In considering why part 2 exercises were omitted at such a high rate, we examined the types of conditioning this section employed. Strengthening, balance, and plyometric type exercises (utilized by part 2) are not included in a traditional warm-up and could potentially cause muscle soreness,¹ especially in a deconditioned athlete. It is possible coaches perceived an increase in injuries associated with this portion of the intervention and chose to modify or omit specific exercises from the IPP. Part 2 also requires more involvement from a coach since hand-timing and cueing are necessary. Last, the time spent on these exercises took on average 13 minutes, the longest of the 3 parts, which to some coaches may have been perceived as an impediment to their practice time.⁷ Specifically, basketball and lacrosse teams were more likely to omit part 2 exercises. Basketball practice court time is very limited, and warm-up routines were often done by the athletes

on their own outside the gym. Lacrosse practice time in the northeast is limited by late snow in April. Teams held abbreviated practices indoors until outdoor facilities were accessible.

Exercise fidelity varied by level of play. Expectedly, varsity teams performed exercises with good technique at higher rates than junior varsity and freshmen teams. Varsity teams typically have stronger, more experienced athletes and coaches, and they are therefore more capable of performing these exercises correctly. This is significant because the approach to implementation was largely the same for all teams, regardless of level of play. A potential solution would be to modify the IPP for the lower level teams with younger athletes when applicable. Coaches might consider incorporating components from the "11+ Kids" IPP to accommodate younger, developing athletes.¹⁴ McKay et al¹⁰ state that delivery of IPPs should be tailored to the specific coach and player in regards to their injury risk knowledge, prevention beliefs, and sport playing experience to help with their endorsement of the program.

The time needed to complete the program may have deterred some teams from executing the program to their full potential. The 11+ IPP is described as taking approximately 20 minutes to complete when athletes are familiar with the exercises,⁴ and while the present study found the full program to take on average 23.8 minutes for athletes to complete, the time required to complete the program ranged from 12 to 39 minutes. The number of athletes, varying exercise intensities, level of focus, and overall familiarity with the program may have led to the large differences in completion time. Finch et al⁶ reported that players believed IPPs to be effective at reducing risk of injury and would participate in the IPPs only if their practice time was not reduced, since that is thought to improve performance.

An important strength of this study was the trial of the IPP at the high school level investigating a large number of teams that varied by sport, sex, and level of play. This diverse population allowed researchers to assess the barriers associated with participation in IPPs. Few studies have carried out observations after implementation of an IPP,^{8,23} especially with the level of detail this study used to assess fidelity. It is important to observe the execution of an intervention, especially when real-world adoption is the goal.

Study Limitations

We acknowledge a few important limitations in the present study. First, weekly compliance data were self-reported by the head coach of each team. Given that coaches hold many biases regarding their teams' physical fitness, it is possible that coaches overestimated the frequency with which their teams performed the intervention, especially their completion of the entire 11+ IPP.⁹ Our RCT did not find a significant relationship between injury rates and frequency of performance of the 11+ IPP with teams that performs the full 11+ program less than once per week having slightly lower injury rates than teams with higher compliance. This suggests that some coaches may have overestimated compliance, although it should be noted that the

efficacy of the 11+ IPP among high school athletes has not been established. Second, observations were intended to be an additional mechanism to assess compliance but had several shortcomings. In many cases, observers were visible to the coaches and players and their presence is likely to have influenced teams to execute the program to a higher standard than they would without an observer present. In addition, despite the presence of a researcher during observed practices, teams rarely completed the 11+ exercises with the technique, volume, and intensity that is required to realize its potential benefits. Third, the observational checklist developed to assess exercise fidelity is inherently subjective and the threshold of one-half of athletes performing an exercise with good technique may be considered too low. Last, the high school athletic setting can be a difficult place to enact large-scale change. It is possible that compliance would have been higher if the intervention was conducted in the club setting where you have greater control over variables such as length of practice time and allotted space to fully execute the IPP.

CONCLUSION

Team compliance with the 11+ IPP varied by sport and was below the recommended amount to observe reduced injury rates from the 11+ intervention. Use of a standardized observational assessment tool should be considered if fidelity of an IPP is of interest. Further research should focus efforts toward reducing implementation barriers and garnering coaches' support to improve adoption of IPPs at all levels of play in the high school setting.

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