MedCrave
Step into the World of Research
International Physical Medicine & Rehabilitation Journal

Literature review

Open Access

The effectiveness of the 11+ at improving sport performance metrics: a systematic review

Abstract

Objective: To conduct a systematic review of the short- and long-term effects of the 11+ warm-up on performance metrics (PMs) in soccer players.

Methods: Eligible studies were written in English; tested adolescent/young adult competitive soccer players; and included same-group pre- and post-test data on 11+-related PMs.

Results: 20 articles met the inclusion criteria. Synthesis found evidence that long-term 11+ exposure resulted in improvements in hamstring strength-related measures; some evidence for improved agility, jump height, static and dynamic balance; limited or conflicting evidence for speed and quadriceps strength; insufficient evidence for dynamic control ratio and kicking skill/accuracy; no evidence for motor control. PM improvements following a single 11+ exposure was limited/conflicting.

Conclusion: Long-term exposure to the 11+ improved hamstring strength. Given the heterogeneous nature of the studies, further research is warranted to understand the programs' effects on PMs in different populations, with consideration of program dosage and athlete's baseline skill.

Keywords: warm-up exercise, soccer, training

Volume 4 Issue 6 - 2019

Matthew Wentzell,[1,2,3] Gerry Ramogida,[1] Amy Schneeberg,[4,5] Allison Ezzat[4,5]

[1]Royal College of Chiropractic Sports Sciences (Canada), Calgary, Alberta, Canada
[2]Department of Occupational Sciences and Occupational Therapy, University of British Columbia, Vancouver, British Columbia, Canada
[3]Department of Physical Therapy, University of British Columbia, Vancouver, British Columbia, Canada
[4]School of Population and Public Health, University of British Columbia, Vancouver, British Columbia, Canada
[5]British Columbia Children's Hospital Research Institute, Vancouver, British Columbia, Canada

Correspondence: Matthew Wentzell, Royal College of Chiropractic Sports Sciences (Canada), Calgary, Alberta, 100-223 Mountain Highway North Vancouver, Canada, V7J 3V3, Canada, Tel 604-356-6986 Email drwentzll@mountainhp.ca

Received: November 13, 2019 | **Published:** November 28, 2019

Abbrevations: 11+, FIFA11+; PMs, performance metrics; SJ, squat jump; MPC, mean percent change; CI, confidence interval; D&B, Modified Downs and Black; UT, Unpublished thesis; QConPT, quadriceps concentric peak torque; HConPT, hamstring concentric peak torque; QEccPT, quadriceps eccentric peak torque; HEccPT, hamstring eccentric peak torque; HCon:QCon, conventional strength ratio; HEcc:QCon, dynamic control ratio; F/S, fast/slow; HIsoNetPT, hamstring isometric net peak torque; QIsoNetPT, quadriceps isometric net peak torque; AddEcc, adductor eccentric strength; RSI, reactive strength index; MVC, maximal voluntary contraction; RFD, rate of force of development; DJ, drop jump; CMJ, countermovement jump; SJ, squat jump; SGJ, Sargent jump; BCMJ, Bosco Counter Movement Jump; YBT, Y-balance test; BESS, balance error scoring system; ST-EO, stork test eyes open; ST-EC, stork test eyes closed; SEBT, star excursion balance test; SL-EC-AP, single leg eyes closed on Airex pad; reg., regular group; comp., comprehensive group; D, dominant; ND, non-dominant; L, left; R, right

Introduction

The 11+ is an internationally recognized warm-up program designed to reduce the incidence of noncontact soccer injuries.[1] The program is the brainchild of the FIFA Medical Assessment and Research Centre, the Oslo Sports Trauma Research Centre, and the Santa Monica Sports Medicine Research Foundation[2] and is comprised of three parts that include aerobic, strength, agility, and plyometric exercises.[3] Since its inception, the injury preventative effects of the 11+ have been examined extensively in different soccer populations. Studies involving adolescent and young adults consistently reported a reduction in lower extremity injuries with regular program use,[4,5] with recent systematic reviews reporting an overall noncontact injury reduction of 30-39%.[5,6] Over the last decade, researchers have also been studying the short- and long-term effects the 11+ on various physical performance metrics (PMs) in different populations.[2,7] Studies looking at the short-term effects of the 11+ have done so by measuring one or more PMs before the warm-up and again within seconds[8] to several minutes[7,8] after the warm-up concluded. The long-term effects of the 11+ have been assessed by changes in PMs after performing 3-6 sessions per week for several weeks[2] to several months.[9] By understanding of the short- and long-term performance effects of the 11+, the underlying protective mechanism responsible for its injury prevention effectiveness may be better understood.[10] Knowing the effects elicited by the 11+ may also help to redesign this standardized warm-up program with the aim of improving its efficacy to modify some injury risk factors sot that the program may have a higher impact on the likelihood of reducing injuries. In addition, the combination of injury prevention and physical performance improvement could be used to encourage program 'buy-in' from coaches and athletes and improve adherence to the program.[9,11]

A previous systematic review examined the impact of the 11+ on PMs.[12] It reported significant improvements in dynamic balance and agility, as well as non-significant improvements in jump height and sprint times in 11+ groups compared to control groups.[12] However, it excluded non-randomized controlled trials, studies with interventions of less than four weeks, and some key PMs (e.g. strength). The present review addresses these limitations and takes a more comprehensive examination of the influence of the 11+ on PMs by including: 1) observational studies; 2) studies that explore immediate performance changes after athlete exposure to the 11+; 3) additional PMs such as strength-related measures. Thus, the aim of this systematic review is to synthesize the evidence to determine if the 11+ improves short- and long-term PMs (speed, agility, jump height, balance, motor control, strength, and kicking skill/accuracy) in competitive adolescent and young adult soccer players.

Methods

Data sources and search strategy

Article collection was performed using the steps outlined by PRISMA.[13] Two reviewers (MW, GR) independently performed identical database searches (January 1, 2008 to September 1, 2018) from the following five electronic databases: Medline, CINAHL, EMBASE, Google Scholar, and SPORTDiscus. Keywords, subject headings and Boolean operators were used in the search strategy. The search focused on three main concepts: 1) the target sport; 2) PMs of interest; 3) the target warm-up (Figure 1). A detailed search history of the five databases is provided in Supplementary File 1. Search limits were imposed when search results retrieved 800 or more articles. Databases were limited to studies involving human adolescents, young adults, or adults (10-44 years of age) that were written in English. PMs were defined as speed, agility, jump height, balance, motor control, strength, and kicking skill/accuracy. Only studies utilizing a testing method that could objectively measure one of the above PMs were included. Only peer-reviewed articles and dissertations were included. Study duplicates from each database search were removed.

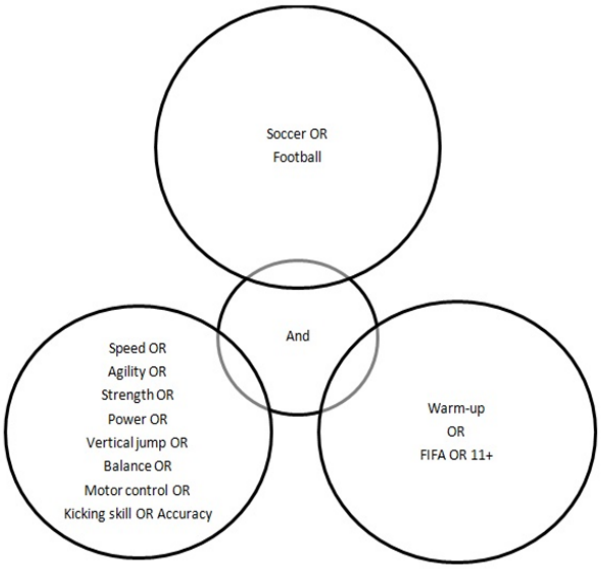

Figure 1 Conceptual model of the implemented search strategy.

Selection of studies

Abstracts were independently screened by two reviewers (MW and GR) for eligibility, followed by an independent full-text review for all articles that met inclusion criteria, or it was unclear based on abstract. The two reviewers compared their eligible studies and came to a consensus for inclusion. In the event of discrepancy between the two reviewers, a third reviewer (AE) was available to make a final decision for inclusion. For inclusion, articles had to: 1) be a prospective, randomized controlled trial, quasi-experimental, or cohort study with or without controls; 2) use the 11+ warm-up in its entirety (i.e. all 3 three parts of the warm-up); 3) study healthy adolescent (10-19 years of age) and young adult (19-40 years of age) competitive soccer players. Competitive soccer was defined as professional, national, amateur, varsity, club, and rep levels of play.

Data extraction and quality assessment

One reviewer (MW) extracted data from the studies including study design, subject demographics, program dosage and progression, PMs, statistical analysis, and mean percent change (MPC) with confidence intervals (CI) or *p*-values when available. MPC and 95% CI were calculated by the authors if this information was not provided in the article, but the data was available to do so. Studies were categorized as measuring the short-term effects of the 11+ if the PMs were measured seconds to minutes after participants completed a single 11+ session. On the contrary post-testing for the long-term effects were measured hours to several days following the completion of their respective intervention periods. Studies measuring the long-term effects of the 11+ if PMs were evaluated following a minimum of 3 weeks of scheduled 11+ warm-ups.

The Modified Downs and Black (D&B) checklist was used to assess the methodological quality of the included studies.[14] Two reviewers (MW and GR) independently applied the D&B criteria to each article for a score ranging from 0 to 28 points. The reviewers compared their scores for individual studies and disagreements were resolved by a third reviewer (AE) if necessary.

Data synthesis

A priori, meta-analyses were to be conducted for all PMs. However, given the heterogeneous nature of studies, the authors concluded that a meta-analysis was not appropriate and that the PMs would be qualitatively synthesized and presented via tables. MPC was used to compare the results across the studies a priori, as it can be calculated by the authors if pre- and post-test PM values are provided.

Results

Literature search

Ninety-three articles were retrieved in the initial literature search of which 54 were duplicates. An additional article was retrieved through a reference list check. Of the forty titles and abstracts screened 11 articles were removed for not meeting inclusion criteria. A total of 29 full-text articles and dissertations were reviewed. An additional 8 articles were removed for not meeting inclusion. The author of one dissertation that met inclusion criteria did not provide approval for use of their data, leaving 20 articles included in this review. The article selection process is illustrated in a PRISMA flow diagram in Figure 2.

Study designs were randomized controlled trials (n=7) and within-group pre-post designed trials (n=13). Nineteen articles studied male populations and 1 article studied female populations. Professional and amateur player cohorts were used in 7 and 5 articles, respectively. The remaining 9 articles used a mix of skill level cohorts ranging from high school to collegiate levels of play. Speed (n=9), agility (n=7), vertical jump (n=10), balance (n=8), kicking skill and accuracy (n=3), quadriceps concentric strength (n=4), hamstrings concentric strength (n=4), and other strength measures (n=9) were addressed. The median value for the D&B scores of all the included studies was 21 with a range from 13-26. Additional characteristics of all included studies are summarized in Table 1.

Of the 20 included studies, 11 studies and one unpublished theses by Rolstad-Martinez (2017) contained MPC values.[2,7,15–23] Seven studies did not provide MPC values, but included the data for them to be calculated.

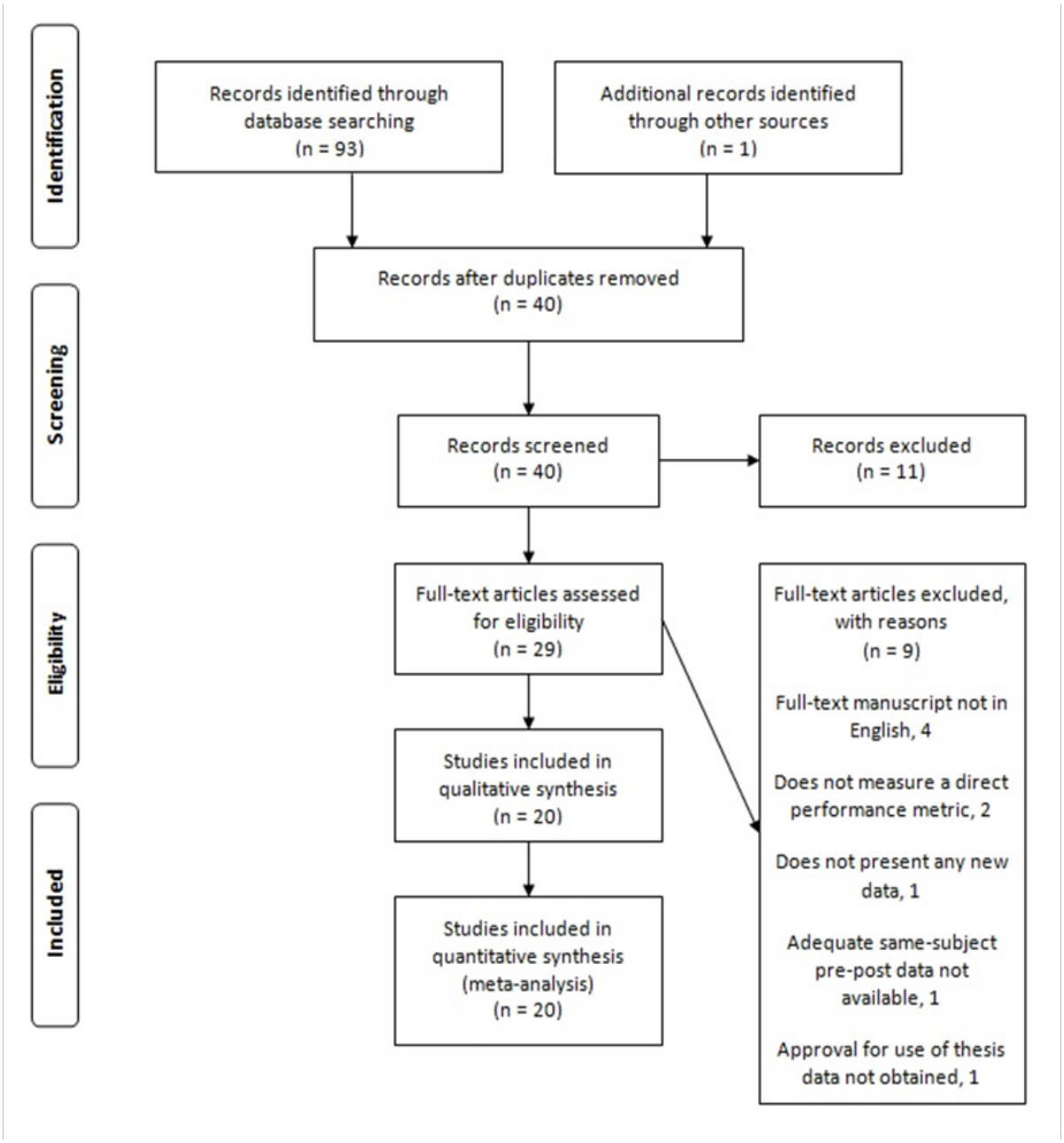

Figure 2 Article selection process using PRISMA flow diagram.

Another study provided pre and post-test data for some PMs, but not all.[24] For consistency, the authors calculated the MPC values for the PMs from all the included studies when pre and post test data was available. The formula [(posttest score - pre-test score)/posttest score x 100] was used to do so. Both MPC values as determined by each study and as determined by the authors of this manuscript are provided in Table 2 through Table 9.

Strength

Ten articles measured strength changes in relation to the 11+ program and are presented in Table 2–Table 4.[2,7,8,16–18,20,21,24,25]A variety of measures were used including peak torque through isokinetic[2,16,17,24] and isometric strength testing,[7,20] dynamic control ratio (DCR),[16,17] reactive strength index (RSI),[8] and anaerobic power via the Bosco Counter Movement Jump 15s (BCMJ),[25] hamstring/quadriceps (H:Q) strength ratio,[16,17] eccentric adductor strength and eccentric hamstring strength corrected for body weight.[21] Two studies looked at the immediate effects of one 11+ session on strength performance[7, 8] while the others measured strength changes after performing the 11+ for 3 to 30 weeks.[2,7,16–18,20,21,24,25]

The 11+ was consistently associated with a statistically significant

improvement in hamstring peak torque at various isokinetic speeds, particularly concentric peak torque in all 4 studies in which it was measured, with MPC improvement ranging from 6.2% to 32.7%.[2,16,17,24] Mixed results were reported across four studies regarding concentric and eccentric quadriceps peak torque production at various isokinetic speeds after several weeks of the 11+.[2,16,17,24] Peak torque production through isometric muscle testing, eccentric hamstring strength corrected for bodyweight, and eccentric adductor strength were studied in one article each. A statistically significant increase in peak torque production through isometric muscle testing[20] and eccentric hamstring strength corrected for bodyweight have been reported, while no change in eccentric adductor strength was been observed following implementation of the 11+.[21] Several studies found improvements in (H:Q) strength ratio with and without statistical significance, with larger improvements seen in the non-dominant leg at slower isokinetic speeds.[16,17] Statistically significant decreases in the DCR of the dominant and non-dominant leg following the 11+ were reported in one study[17] while another study reported a statistically significant improvement in non-dominant leg only.[16] A single study examined each of anaerobic power measured through the BCMJ, force production through isometric testing and RSI scores following 11+ with a positive statistically significant finding for the former and non-significant negative effect for the latter two.[7,8,25]

Of the 20 studies, 6 examined hamstring strength and all found the 11+ led to statistically significant improvement. Five of the 20 studies examined quadriceps strength and 4 found the 11+ led to statistically significant improvement in a minimum of one strength measurement. Fewer measurements within each respective study were statistically significant for quadriceps strength relative to hamstrings strength. No studies found significant improvement in short-term strength-related PMs following the 11+.[7,8]

Agility

Seven articles examined changes in agility following exposure to the 11+ and are presented in Table 5.[2, 4, 8, 15, 19, 23, 25] Four articles used the Illinois Agility test,[15, 19, 23, 25] two used the Agility T-test,[2, 7] and one used the 505 Agility test.[8] Two articles focused on immediate changes in agility performance following a single 11+ session[7, 8] with one reporting favorable and significant changes[7] while the other reported no benefit.[8] Five articles focused on agility changes following 4 to 30 weeks of the 11+.[2, 15, 19, 23, 25] Four articles reported favorable and significant improvements in MPC ranging from -1.7% to -19.7%[19, 23, 25] while two reported a favorable but statistically non-significant trend in agility performance.[2, 15]

Vertical jump height

Ten studies examined change in vertical jump height following exposure to the 11+ and are presented in Table 6.[1,2,8,11,15,19,22,23– 26] Vertical jump height was assessed using drop vertical jump (DVJ).[8,11,15] squat jump (SJ),[7,19,22,23] counter movement jump (CMJ),[2,7,22] and Sargent jump tests.[19,26] Two studies focused on immediate changes in vertical jump height following a single 11+ session with one reporting favorable and significant improvement in jump performance,[7] although recalculation suggests one of the two tests used resulted in a decreased jump performance. The other study on immediate jump height changes reported a negative and non-significant performance trend.[8] Eight articles measured jump performance after their subjects completed between 4 and 30 weeks of the 11+ program.[2,11,15,19,22,23,25,26] Six studies reported favorable and significant improvement in jump performance with some studies reporting an MPC from 3.7% to 12.9%,[15, 19, 22, 23, 25, 26] one study had a negative value indicating a decrease in jump height performance,[15] and two studies reported no change in jump height.[2,11]

Balance

Eight studies looked at measures of static and dynamic balance and are presented in Table 7.[2,7,9,11,15,24,27,28] Dynamic balance was measured using the Y-Balance test[11,15,28] and the Star Excursion Balance Test (SEBT).[2,7, 9,27] Static balance was measured using the Biodex Balance System,[24] the Balance Error Scoring System,[28] single-leg eyes closed balance on Airex pad,[9] and the Stork test.[27] A single article looked at the immediate effects the 11+ has on dynamic balance and reported a favorable and significant change.[7] Of the six studies measuring dynamic balance change between 4 and 18 weeks of the 11+, four reported favorable and significant improvement in MPC ranging from 2.1% to 10.2%.[9,15,27,28] Five studies measured static balance change after 3 to 18 weeks of the 11+ and three reported favorable and significant improvement.[9,27,28] The significant improvements in static balance MPC ranged from 4.1% to 69.3%.[9,27]

Speed

Eight studies and one unpublished thesis by Rolstad-Martinez (2017) examined changes in speed following the implementation of the 11+ program and are presented in Table 8.[2,7,11,15,,19,21,23,25] Rolstad-Martinez (2017) and seven other studies focused on speed-related changes following 4 to 30 weeks of the 11+,[2,11,15,19,21,23,25] with five reporting statistically significant posttest improvements in MPC ranging from -1.8% to -24.2%.[2,15,19,23,25]Three studies, including the Rolstad-Martinez (2017) thesis, reported no change in posttest times.[11, 21] One study addressed short-term changes in speed following a single 11+ session and reported favorable and significant improvement of -2.2% compared to pretest values.[7]

Kicking skill/accuracy

Three studies looked at the 11+ warm-ups impact on kicking skill and accuracy and are presented in Table 9.[19,23,28] Two studies used the wall-volley test[19,23] while the other used a novel test using a limited number of kicks to contact targets with varying point values.[28] Improvement in kicking skill and accuracy was only found in one study.[19]

Motor control

No studies were found that looked at the 11+ warm-ups impact on motor control.

Discussion

The main finding of this review is that there is consistent evidence for significant improvements in hamstring-related strength measures in the majority of studies (6 of 6=100%) that examined them.[2,16,18,20,21,24] There is also some evidence for improvements in agility, jump, speed, static and dynamic balance measures after the long-term implementation of the 11+. The evidence supporting improvements in the remainder of the PMs in both the short-term and long-term is limited, conflicting, or insufficient.

The 11+ consists of a series of exercises that may help to improve measures of strength such as squat and lunge variations, as well as the Nordic Hamstring Curl.[1] Favorable improvements in concentric hamstring torque were found at slow,[2,16,18,24] medium,[2,16,18,24] and

high speeds[18,24] suggesting both concentric slow-speed strength and explosiveness and power improve with the 11+.[24] Harøy et al.[21] reports the Nordic Hamstring Curl is designed to primarily target eccentric hamstring strength and the findings of the current review support improvement in this metric, albeit less consistently than the improvements seen in concentric hamstrings strength.

The findings for concentric quadriceps peak torque production were mixed and less consistent than those found for the hamstrings. The 11+ appears to have little benefit on peak torque production at slower concentric speeds.[2,18,24] and greater influence on peak torque production at mid and high speeds.[16,18,24] It is possible that this improvement may be related to the squat jump variations included in the warm-up. Improvements in quadriceps and hamstrings isokinetic strength are likely due to the 11+ since isokinetic strength has shown to remain consistent over the course of a soccer season.[29]

Results from isometric testing report favorable quadriceps and hamstring peak torque production in ranges that put the muscle in mid-range to their most lengthened positions.[20] The degree of improvement in both muscle groups was greater with joint angles that progressively lengthened both muscle groups suggesting that the 11+ has a greater effect on agonist muscle strength in elongated positions. Interestingly, quadriceps peak torque was lower at baseline for each knee angle tested on the non-dominant side and the posttest improvements in peak torque were markedly greater on the same side.[20] The 11+ may have a greater training effect on the weaker side, resulting in more symmetrical quadriceps torque production via isometric testing.

The (H:Q) strength ratio is derived by comparing the concentric peak net torque of the hamstrings to that of the concentric peak net torque of the quadriceps at a matched angular velocity.[17] The two studies measuring H:Q strength ratios reported favorable and significant change in the non-dominant leg at slower speed values, meaning greater post-test improvement in hamstring strength relative to quadriceps strength on the non-dominant side occurred with exposure to the 11+.[16,17]

The Dynamic Control Ratio (DCR) is calculated by dividing the eccentric peak net torque of the hamstrings by the concentric peak net torque of the quadriceps.[17] Studies measuring DCR yielded conflicting results[16,17] and are difficult to compare since DCR was measured using different quadriceps and hamstring angular velocity values. A decreased DCR implies the quadriceps isokinetic strength improved more than hamstring isokinetic strength. Although greater quadriceps isokinetic strength has a positive effect on ball kicking speed,[30] a decreased DCR is unlikely to benefit the players health since the hamstrings may not be able to protect against the sheering forces at the joint with forceful knee extension.[31]

Reactive strength index (RSI) and the Bosco Countermovement Jump (BCMJ) are similar in that they both measure explosive strength. RSI is calculated by dividing counter movement jump (CMJ) height that follows a drop jump (DJ) by the contact time on a force platform prior to CMJ take-off[32] while the BCMJ does so through a formula accounting for flight time, force of gravity and number of jumps over a 15 second interval.[25] RSI was measured in one study after subjects completed a single session of the 11+.[8] Posttest RSI values trended negatively but did not reach statistical significance.[8] It is possible the warm-up induced player fatigue leading to the negative trend in RSI performance. Only one study measured anaerobic power through the BCMJ and it reported a significant improvement following 30 weeks of the 11+.[19] It is plausible that the squat and jumping components of the 11+ contributed to this increased performance.[19]

Three of six articles (50%) reported favorable and statistically significant change in agility following weeks of exposure to the 11+.[19,23,25] The final exercise in the 11+ is a high intensity exercise that involves a plant and cut maneuver to change directions quickly without inward buckling of the knee.[1] Of note, one group reporting a nearly 20% improvement in agility times engaged in more than double the 11+ exposures than that of the other groups[23] suggesting a dose-response relationship. A total of four different agility tests were used in the eight studies measuring pre- and posttest agility performance, which limits the generalizations that can be garnered from these results.

Less PM variability existed when examining changes in speed with adoption of the 11+, however some conflicting results were noted in studies that used similar populations and intervention setups.[11,15] Likewise, in two studies with players of the same sex and skill level,[2,15] the one study with over twice the 11+ exposures, found non-significant results.[2] Disparity in these findings may be due to differences in the performance capabilities of each athlete. The 11+ may be challenging enough to elicit a training response in some players while inadequate for others regardless of their age and skill level.

The 11+ includes jump squat, lateral jump and box jump exercises.[1] Six of eight (75%) articles measuring change in jump height after several weeks of the 11+ reported favorable, significant improvement.[15,19,22,23,25,26] The tests used to measure vertical jump height varied across studies. Different jump tests place different physiological demands on the subject. For instance, DVJ and CMJ harness force production via eccentric and concentric load through the lower extremities. The rapid transition from eccentric to concentric load is known as the stretch-shortening cycle and provides elastic energy for use prior to propulsion off the ground.[22] SJ and the Sargent Jump lack countermovement prior to the jump and are therefore more dependent on concentric force production.[22,25]

Both static and dynamic balance are trained through the use of the 11+ program. Static balance is trained through stationary single-leg exercises and dynamic balance is promoted through emphasizing the intent of sticking the landings from multi-directional movements while maintaining ankle, knee and hip alignment.[1] Four articles testing static balance yielded mixed results with some studies showing favorable, significant improvement[9,27] while others did not.[24,25] Five studies looked at change in dynamic balance after several weeks of the 11+[2,9,15,27,28] with four studies reporting favorable and substantial change in posttest scores.[9,15,27,28] Population heterogeneity means it is challenging to establish any overarching trends with respect to balance improvements due to adopting the 11+. One study tested females[9] while the other five tested male populations.[2,15,24,27,28] Skill level ranged from competitive U16 players[9] to professional level players.[27] The single study examining changes in dynamic balance following one 11+ session reported a favorable, statistically significant change in dynamic balance suggesting the 11+ may result in an acute positive neuromuscular response.[7]

The evidence suggesting that the 11+ can improve kicking skill and accuracy is weak relative to other PMs, which is unsurprising given that the 11+ does not include a soccer ball-kicking element. However, one study reported a significant improvement in kicking skill and accuracy[19] and two studies reported non-significant change that trended towards improvement.[23,28] Improvements in balance have been correlated to improvements in kicking accuracy,[33] which could explain this positive trend.

The 11+ manual advises that the warm-up be performed in its

entirety a minimum of twice per week, and the running elements of the program be performed prior to every soccer match.[1] For the studies included in this review, the warm-up was predominantly performed 3 times per week. One study, which had an intervention frequency double that of most other studies, reported sizeable improvements across a number of PMs.[23] This preliminary finding suggests there may be a dose-response relationship for the association between 11+ and PM improvements.

The 11+ manual suggests 10 to 12 weeks are required for the program to have an injury prevention effect.[1] All but 3 studies discontinued the intervention before the 10 week mark,[9,16,25] yet many of these reported PM improvements. This trend suggests that improvements in PMs may precede favorable improvements in injury prevention. A single 11+ warm-up preceding a training session also improved several PMs in one study.[7] This should be considered possibly beneficial for players attending the training session, and may be one of the reasons behind the preventive effects of the program. These benefits may be attributable to post activation potentiation of some key muscle groups[7] given that the second part of the 11+ has been shown to increase activation of the rectus abdominus, gluteus medius and gluteus minimus muscles.[34]

Fifteen of the 20 articles (75%) involved adolescent soccer populations. The remaining 5 articles tested young adult players in the early to mid-20's.[2,7,8,16,23] No trend appears with respect to a particular age group responding more favorably to the 11+. However, one study postulated that the 11+ may not be rigorous enough to elicit a training effect in adult populations.[27] As more studies are conducted using comparable intervention frequencies, durations, skill level progressions, age-related PM changes may emerge.

The majority of the studies in this review focus on PM changes in men following 11+ exposure. There are an estimated 40 million female soccer players worldwide[35] and to the authors knowledge, only one group have studied PM changes in females following the 11+.[9] PM response to the 11+ is largely unknown for female players across all ages and skill levels. More research is needed to examine female players to be able to delineate whether there are any sex-related differences with respect to the PM response to the 11+.

It has been suggested that professional soccer players may be most likely to see improvements in neuromuscular performance after implementing the 11+.[11] Across most PMs, professional players consistently reported favorable and significant change.[20,22,23] However, it should be noted that 5 of the 20 articles included in this review were written by the same authors[17,20,27] using the same subject pool for all five studies. Improvements in populations of inferior skill levels are less consistent.

Only one study compared and contrasted the performance effects of the 11+ on age-and skill-matched populations based on their adherence to the program, but preliminary research suggests that higher adherence yields more favorable results, at least in static and dynamic balance.[9] More research on 11+ adherence of age- and skill-matched players is warranted as it could provide insight on optimal program dosing from a performance perspective.

Limitations of included studies

Many articles lack a comparison group making it difficult to determine if PM changes are influenced by subject motivation, expectations, the passage of time or due to other aspects of training. The majority of the articles also have a small sample size with 9 to 15 players in their intervention groups. This makes generalizing the findings of each study difficult, particularly when combined with a broad array of outcome measures and variations in intervention frequency, duration and difficulty level progression. Several studies did not provide MPC values and two studies did not provide pre and post-test data which could subsequently be used to calculate the MPC of various PMs. Future studies should also address factors related to internal validity such as adequate blinding and randomization procedures.

Limitations

Several limitations are noted in the current review. The literature search excluded studies that were not written in English, and this resulted in the exclusion of four studies (Figure 2). These papers could possibly provide a greater understanding of the performance effects of the 11+ program. Although the literature searches were performed by two independent reviewers, it is possible that some articles could have been missed through the screening process. The heterogeneous nature of the articles did not allow the authors to perform a meta-analysis. This limitation detracts from the authors' ability to extrapolate findings from the included studies.

Conclusion

The most consistent improvements in PMs related to the 11+ are with regards to hamstring strength-related measures. There is also some evidence for the 11+ having a positive long-term effect on H:Q strength ratios, agility, speed, static and dynamic balance and vertical jump height. Improvements in these PMs may serve as an additional motivating factor for program promotion and may help improve coach and player buy-in and program adherence. The evidence for long-term improvement in the remainder of the PMs is limited, insufficient or conflicting and there is limited evidence on the short-term performance effects of the 11+ in all PMs.

Caution should be had when making general inferences based on this systematic review. All but one performance-related 11+ study has been conducted on male soccer populations indicating a significant lack of research on female populations. The 11+ is first and foremost an injury reduction warm-up and more research is strongly warranted to improve our understanding of its short- and long-term effects on various PMs in different populations. Future research should also give consideration to how program dosage, player adherence, and athlete's baseline skill influence the 11+ effect on PMs.

Acknowledgments

The authors would like to thank the FOUNDATION for the Royal College of Chiropractic Sports Sciences (Canada) for their post-hoc funding contribution for the development of this systematic review.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Bizzini M, Junge A, Dvorak J. The "11 " manual. A complete warmup programme to prevent injuries. Zurich: FIFA Medical Assessment and Research Centre. 2011.

2. Impellizzeri FM, Bizzini M, Dvorak J, et al. Physiological and performance responses to the FIFA 11 (part 2): A randomised controlled trial on the training effects. *J Sports Sci*. 2013;31(13):1491–502.

3. Soligard T, Myklebust G, Steffen K, et al. Comprehensive warm-up programme to prevent injuries in young female footballers: Cluster randomised controlled trial. *BMJ*. 2008;9:337:a2469.
4. Bizzini M, Dvorak J. FIFA 11+: An effective programme to prevent football injuries in various player groups worldwide-a narrative review. *Br J Sports Med*. 2015;49(9):577–579.
5. Sadigursky D, Braid JA, De Lira DNL, et al. The FIFA 11 injury prevention program for soccer players: A systematic review. *BMC Sports Sci Med Rehabilitat*. 2017;9(18):1–8.
6. Thorborg K, Krommes KK, Esteve E, et al. Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: A systematic review and meta-analysis of the FIFA 11 and 11+ programmes. *Br J Sports Med*. 2017;51(7):562–571.
7. Bizzini M, Impellizzeri FM, Dvorak J, et al. Physiological and performance responses to the "FIFA 11 "(part 1): Is it an appropriate warm-up?. *J Sports Sci*. 2013;31(13):1481–1490.
8. Cloak R, Nevill A, Smith J, Wyon M. The acute effects of vibration stimulus following FIFA 11 on agility and reactive strength in collegiate soccer players. *J Sport Health Sci*. 2014;3(4):293–298.
9. Steffen K, Emery CA, Romiti M, et al. High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in canadian youth female football players: A cluster randomised trial. *Br J Sports Med*. 2013;47(12):794–-802.
10. Rössler R, Donath L, Verhagen E, et al. Exercise-based injury prevention in child and adolescent sport: A systematic review and meta-analysis. *Sports Med*. 2014;44(12):1733–1748.
11. Robles-Palazón FJ, Pomares-Noguera C, Rodríguez FA, et al. Acute and chronic effects of the FIFA 11 on several physical performance measures in adolescent football players. *Eur J Hum Mov*. 2016;36:116–136.
12. Gomes Neto M, Conceição CS, de Lima Brasileiro AJA, et al. Effects of the FIFA 11 training program on injury prevention and performance in football players: A systematic review and meta-analysis. *Clin Rehabil*. 2017;31(5):651–659.
13. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Med*. 2009;6(7):e1000100.
14. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health*. 1998;52(6):377–384.
15. Ayala F, Pomares-Noguera C, Robles-Palazón FJ, et al. Training effects of the FIFA 11 and harmoknee on several neuromuscular parameters of physical performance measures. *Int J Sports Med*. 2017;38(04):278–289.
16. Brito J, Figueiredo P, Fernandes L, et al. Isokinetic strength effects of FIFA's" the 11 " injury prevention training programme. *Isokinet Exerc Sci*. 2010;18(4):211–215.
17. Daneshjoo A, Mokhtar AH, Rahnama N, et al. The effects of injury preventive warm-up programs on knee strength ratio in young male professional soccer players. *PloS one*. 2012;7(12):e50979.
18. Daneshjoo A, Mokhtar A, Rahnama N, et al. The effects of injury prevention warm-up programmes on knee strength in male soccer players. *Biol Sport*. 2013;30(4):281–288.
19. Daneshjoo A, Mokhtar AH, Rahnama N, et al. Effects of the 11+ and harmoknee warm-up programs on physical performance measures in professional soccer players. *J Sports Sci Med*. 2013;12(3):489–496.
20. Daneshjoo A, Rahnama N, Mokhtar AH, et al. Effectiveness of injury prevention programs on developing quadriceps and hamstrings strength of young male professional soccer players. *J Hum Kinet*. 2013;39:115–125.
21. Harøy J, Thorborg K, Serner A, et al. Including the copenhagen adduction exercise in the FIFA 11 provides missing eccentric hip adduction strength effect in male soccer players: A randomized controlled trial. *Am J Sports Med*. 2017;45(13):3052–3059.
22. Silva JRLdC, Silva JFd, Salvador PCdN, et al. The effect of "FIFA 11 " on vertical jump performance in soccer players. *Brazilian J Kineanthropometry Hum Perform*. 2015;17(6):733–741.
23. Sharma A, Sayyad A. Effects of the FIFA 11+ and harmoknee warm-up programs on physical performance measures in elite football players. The Physiotherapy. 2016;1(1):1-6.
24. Ghareeb DM, McLaine AJ, Wojcik JR, et al. Effects of two warm-up programs on balance and isokinetic strength in male high school soccer players. *J Strength Cond Res*. 2017;31(2):372–329.
25. Zarei M, Abbasi H, Daneshjoo A, et al. Long-term effects of the 11 warm-up injury prevention programme on physical performance in adolescent male football players: A cluster-randomised controlled trial. *J Sports Sci*. 2018;36(21):2447–24-54.
26. Akbari H, Sahebozamani M, Daneshjoo A, Amiri-Khorasani M. Effect of the FIFA 11 programme on vertical jump performance in elite male youth soccer players. *Montenegrin J Sports Sci Med*. 2018;7(2):17–22.
27. Daneshjoo A, Mokhtar AH, Rahnama N, et al. The effects of comprehensive warm-up programs on proprioception, static and dynamic balance on male soccer players. *PloS one*. 2012;7(12):e51568.
28. Dunsky A, Barzilay I, Fox O. Effect of a specialized injury prevention program on static balance, dynamic balance and kicking accuracy of young soccer players. *World J Orthop*. 2017;8(4):317–321.
29. Malliou P, Ispirlidis I, Beneka A, et al. Vertical jump and knee extensors isokinetic performance in professional soccer players related to the phase of the training period. *Isokinet Exerc Sci.* 2003;11(3):–169.
30. Tourny-Chollet C, Leroy D. Conventional vs. dynamic hamstring-quadriceps strength ratios: A comparison between players and sedentary subjects. *Isokinet Exerc Sci*. 2002;10(4):183–192.
31. Croisier J, Ganteaume S, Binet J, et al. Strength imbalances and prevention of hamstring injury in professional soccer players: A prospective study. *Am J Sports Med*. 2008;36(8):1469–1475.
32. Young W. Laboratory strength assessment of athletes. *New Stud Athl*. 1995;10:89.
33. Tracey S, Anderson DI, Hamel KA, et al. Kicking performance in relation to balance ability over the support leg. *Hum Mov Sci*. 2012;31(6):1615–1623.
34. Nakase J, Inaki A, Mochizuki T, et al. Whole body muscle activity during the FIFA 11 program evaluated by positron emission tomography. *PloS one*. 2013;8(9):e73898.
35. FIFA. FIFA women's football survey. Zurich: FIFA Medical assessment and research centre; 2014.

Citation: Wentzell M, Ramogida G, Schneeberg A, et al. The effectiveness of the 11+ at improving sport performance metrics: a systematic review. *Int Phys Med Rehab J.* 2019;4(6):281–287. DOI: 10.15406/ipmrj.2019.04.00218