Could Slackline Training Complement the FIFA 11+ Programme Regarding Training of Neuromuscular Control?

Tobias Jäger, Julian Kiefer, Inge Werner & Peter A. Federolf

To cite this article: Tobias Jäger, Julian Kiefer, Inge Werner & Peter A. Federolf (2017) Could Slackline Training Complement the FIFA 11+ Programme Regarding Training of Neuromuscular Control?, European Journal of Sport Science, 17:8, 1021-1028, DOI: 10.1080/17461391.2017.1347204

To link to this article: https://doi.org/10.1080/17461391.2017.1347204
ORIGINAL ARTICLE

Could Slackline Training Complement the FIFA 11+ Programme Regarding Training of Neuromuscular Control?

TOBIAS JÄGER, JULIAN KIEFER, INGE WERNER, & PETER A. FEDEROLF

Department of Sport Science, University of Innsbruck, Innsbruck, Austria

Abstract
The current study compared changes in neuromuscular control between slackline training and the stabilization training elements of the FIFA 11+ programme. Twenty-five students in 2 groups performed a 12-unit training programme. The slackline training group ($n=13$) exclusively trained with a slackline. The stabilization training group ($n=12$) practised exercises as described in the second part of the FIFA 11+ programme. Improvements in balance were assessed using three tests for dynamic, quasi-static, and perturbed postural control: the star excursion balance test (SEBT), the closed-eye single-leg stance, and the MFT S3-Check. Both groups significantly improved the stability and sensorimotor index of the MFT S3-Check ($p < .001$), their range on the SEBT ($p < .001$), and the duration of closed-eye single-leg stance ($p < .001$). The group × training interaction was significant for the MFT S3-Check (stability index: $p = .042$; sensorimotor index: $p = .004$) and the SEBT (dominant leg: $p = .003$; averaged both legs: $p = .016$), with the slackline training group showing a larger training effect than the stabilization training group. The results of the present study suggest that slackline training offers similar – or better – improvements in neuromuscular control as the FIFA 11+ warm-up programme. If compliance with the FIFA 11+ programme is declining, then slacklining might offer an alternative approach to reach the training goals of improved sensorimotor control.

Keywords: Injury & prevention, exercise, training, motor control

Introduction
Many injury prevention programmes developed and tested in the last decades reported a marked reduction of injuries (Mandelbaum et al., 2005; Olsen, Myklebust, Engebretsen, Holme, & Bahr, 2005). This success has led to sport specific programmes such as the “FIFA 11” (Kilding, Tunstall, & Kuzmic, 2008) or its successor, the “FIFA 11+” (Soligard et al., 2008) promoted by the Fédération Internationale de Football Association (FIFA). The FIFA 11+ programme is designed as a 15–20-minute 3-parts warm-up programme that comprises running and stretching exercises; exercises focusing on core/leg strength, balance, and plyometrics; and exercises combining running and agility (F-MARC). With few exceptions (Gatterer, Ruedl, Faulhaber, Regele, & Burtscher, 2012), the FIFA 11+ programme was capable of reducing soccer injury rates by 30–70% (Owoeye, Akinbo, Tella, & Olawale, 2014; Rössler, Donath, Bizzini, & Faude, 2016; Silvers-Granelli et al., 2015). Significant injury reduction has also been reported when the 11+ programme was applied in other sports, for instance, in elite basketball (Longo et al., 2012).

Prevention programmes like the FIFA 11+, however, can only be effective if the training intervention is conducted regularly. Several studies documented a direct relationship between compliance with the programme and injury rates (Silvers-Granelli et al., 2015; Steffen, Meeuwisse, et al., 2013). Hägglund, Atroshi, Wagner, and Waldén (2013) found that team and player compliance significantly deteriorated over the season (Hägglund et al., 2013). This deterioration could indicate a decline in the coaches’ attitude towards the prevention programme or in the motivation of the players (Hägglund et al.,...
The players’ motivation is influenced by many factors, such as content, relevance, and perceived difficulty of the intervention (Soligard et al., 2010). One may speculate that diversifying the spectrum of exercises after several weeks into the intervention programme might provide the new challenges that keep the programme interesting and motivate the athletes to adhere to the programme (O`Brien, Young, & Finch, 2017).

One main component of all injury prevention programmes is the training of sensorimotor control. In fact, the main functional changes observed in athletes after several weeks of FIFA 11+ training appear to be changes in variables characterizing balance and neuromuscular control (Impellizzeri et al., 2013; Steffen, Meeuwisse, et al., 2013) and, conversely, some studies indicate reduced injury rates in athletes with good balance (Hrysomallis, 2007; McGuine, Greene, Best, & Levers, 2000). Hence, additional exercises that improve neuromuscular control might provide one approach to diversify or complement the training exercises of the FIFA 11+ programme.

Slacklining, that is, balancing on an elastic polyester ribbon stretched between two anchor points, is an emerging recreational sports activity that was originally practised by climbers to improve balance and core strength. Nowadays, it is a popular sports activity, frequently used as training and therapy tool (Donath, Roth, Zahner, & Faude, 2016b; Gabel, Osborne, & Burkett, 2015). If slackline training might offer similar improvements in neuromuscular control as the FIFA 11+ programme, then it might represent one possible approach to diversify the FIFA 11+ exercises. Slackline training was shown to improve postural stability (Keller, Pfusterschmied, Buchecker, Müller, & Taube, 2012; Pfusterschmied, Buchecker, et al., 2013), muscle strength (Granacher, Iten, Roth, & Golliofer, 2010), and led to changes in neurophysiological control (Keller et al., 2012; Pfusterschmied, Stöggl, et al., 2013). However, limited transfer effects of slackline training to other postural stability skills were reported for children (Donath et al., 2013) and seniors (Donath et al., 2014; Donath, Roth, Zahner, & Faude, 2016a). A recent meta-analysis (Donath et al., 2016) investigated the transfer effect of slackline training to dynamic balance performance based on data from 158 subjects (83 intervention; 75 control; all ages) in 6 studies and found moderate, yet significant ($p = .02$) transfer effects. The transfer to static balance performance was small and did not reach statistical significance ($p = .07$) (Donath et al., 2016). Hence, the purpose of the current study was to directly compare changes in balance and neuromuscular control between slackline training and the stabilization training elements of the FIFA 11+ programme. We hypothesized that both training programmes would lead to similar improvements in variables characterizing neuromuscular control.

**Materials and methods**

A convenience sample of 28 healthy and athletic students volunteered for the current study; however, 3 participants dropped out for reasons unrelated to the study. Only students who regularly ($\geq$ twice per week) engage in sports were selected in order to match the FIFA11+ target population. Not only soccer players were admitted into the study, since the use of FIFA 11+ was also recommended for injury prevention in other sports (Longo et al., 2012). Each participant completed an anamnesis questionnaire and signed an informed consent form prior to participating. The current study was approved by the institution’s Board for Ethical Questions in Science and was performed according to the Declaration of Helsinki.

Two groups were formed, a slackline training group [SLT] and a FIFA 11+ stabilization training group [F-STAB]. The subjects were allowed to choose their group. The SLT group included 10 women and 3 men (age $22.5 \pm 2.7$; body weight $64.4 \pm 9.9$ kg; height $1.70 \pm 0.07$ m; mean $\pm$ standard deviation). The F-STAB group included 9 women and 3 men (age $23.7 \pm 1.8$; body weight $61.9 \pm 7.3$ kg; height $1.68 \pm 0.06$ m). Prior to participating in the current study, all volunteers answered questions to determine their dominant leg and rated their slacklining skills and their experience with balance training on a 5-point Likert scale ($1 = $ no experience, $5 = $ better than advanced).

All subjects underwent an initial screening of their postural stability, then participated in a six-week training programme specific for their training group, and finally performed a post-training balance and postural control assessment. A schematic overview of the testing and training procedures is shown in Figure 1(a). Both groups started their training sessions one day after the initial tests. Post-training tests were conducted one to three days after the last training unit. During the training phase, no restrictions regarding participation in other sports were given and subjects were encouraged to maintain their usual level of physical activity.

The pre- and post-training assessment of postural stability was conducted using tests for dynamic, quasi-static and perturbed postural control, specifically, the star excursion balance test (SEBT), a
closed-eye single-leg stance, and the MFT S3-Check (Figure 1(b)-(d)).

The SEBT is a well-established test of dynamic postural control (Gribble, Hertel, & Plisky, 2012) with high between-session reliability (Munro & Herrington, 2010). It has been related to lower extremity injury risk (Plisky, Rauh, Kaminski, & Underwood, 2006). The SEBT consists of 16 individual tests, 8 on each foot, in which the participant reaches out with the free foot on an 8-axial star as far as possible. This position is held for a few seconds by supporting the weight on the stance leg and holding the hands on the hips (Figure 1(b)). A test was repeated if participants lost their balance or moved the supporting leg. Breaks between tests were given as needed. All participants executed this test twice per foot. The SEBT excursion distances (in cm) in all directions were averaged over the two trials to yield a variable that characterized the participant’s dynamic postural control. Specifically, the cumulated reach distances for the dominant leg, the non-dominant leg and the mean of both legs were analysed as dependent variables in the current study.

The closed-eye single-leg stance is a frequently applied balance measure often used in slackline research (Keller et al., 2012; Pfusterschmied, Buchecker, et al., 2013; Pfusterschmied, Stöggli, et al., 2013) with moderate-to-high reliability (Birmingham, 2000). In the current study, participants were instructed to stand on a balance pad (Airex AG, Sins, Switzerland) with their eyes closed on one leg (see Figure 1(c)) as long as possible. Before the measurement, the participants stood on the pad, lifted one leg, and were allowed to find their balance. Then they closed their eyes and signalled to the test administrator to start taking the time. The time was stopped when subjects opened their eyes, touched the floor with the second leg, or when they accomplished to stand for more than 180 s. This procedure was repeated three times on each leg and the mean of the two best trials on the dominant leg and on the non-dominant leg as well as the mean of the two best trials on both legs were used as dependent variables.

The MFT S3-Check (TST Trend Sport Trading GmbH., Großhöflein, Austria) is an instrumented unstable board (Figure 1(d)) that has been validated as a platform for evaluating stability, symmetry, and sensorimotor function (Raschner et al., 2008). Between-session reliability has been reported as moderate to very high (Raschner et al., 2008). In the present study, participants first familiarized themselves with the device and started the testing when they felt ready. They performed three trials in which
they tried to keep the board horizontal and as steady as possible. The first 5s were disregarded, the following 30s were used to calculate a sensorimotor index from the amplitude of the platform movements and a stability index from the platform’s deviation from the horizontal (Raschner et al., 2008). High scores (up to 9) represent week, low scores (starting with 1) represent a high level of postural control. For each index, the mean of the two best trials was used for the statistical analysis.

The SLT group completed 12 training units of 20 min during a 6-week period. Each training session was performed in subgroups of maximally four participants who trained exclusively with a slackline (width 25.3 mm; fracture strain 2–3%) spanned either indoors on a wooden frame (2 m) or outdoors between two trees. All units were supervised by a test administrator who prepared a short warm-up and different exercises designed to improve stability. The difficulty of these exercises was progressively increased. Early in the training period, they included the use of a bar or assistance by another volunteer; later, they included dynamic movements, for instance, turning, swinging, or jumping on the slackline. The difficulty level was also increased by extending the length and reducing the tightness of the slackline.

The F-STAB group trained for 4 weeks with three 20-minute units per week. Each training session was performed in subgroups of maximally four participants. Two units per week were supervised by a test administrator; the third unit participants conducted individually according to written instructions handed out each week. The exercises were taken from the FIFA 11+ programme (F-MARC) which is divided into three parts focusing on different running and strengthening exercises. The present study applied the second part of the programme containing “[…] six sets of exercises focusing on core and leg strength, balance and plyometrics/agility, each with three levels of increasing difficulty […]” (F-MARC). These exercises were complemented by additional stabilization exercises, such as rope skipping, running, single-leg stance, and jumps, to reach an equal training duration as in the SLT group.

Data were analysed using SPSS (SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc.). Following a descriptive analysis, data were tested regarding a normal distribution using the Shapiro–Wilk test. The results of the MFT S3-Check and the SEBT were analysed using a repeated-measures analysis of variance (rANOVA). As an additional confirmatory test, we also conducted a rANCOVA using the baseline measures as covariates; however, none of the covariates was significant and the conclusions did not change. Results of the closed-eye single-leg stance were not normally distributed for 8 out of 12 variables and were therefore evaluated using the corresponding non-parametric tests. Differences between the two groups before and after training were tested separately using t-tests and Mann–Whitney-U tests. The threshold for statistical significance was set to α = 0.05.

Results

There were no significant differences between the SLT and the F-STAB group in age (p = 0.225), height (p = 0.654), or weight (p = 0.503). Prior to the training programme, participants of the SLT group rated their slacklining skills with 2.08 ± 0.49 and their experience regarding balance training with 2.75 ± 0.75. Subjects of the F-STAB group self-assessed their slacklining skills with 2.00 ± 1.04 and their balance training experience with 2.74 ± 0.75. Neither in the slacklining skills (p = .819) nor in the experience with balance training (p = .215) there was a statistical difference between the two groups. None of the eight measures for balance and sensorimotor control showed group differences in the pre-training values (Table I, column 10).

All of the eight dependent variables used in the current study indicated a highly significant improvement of postural control due to training (Figure 2). Furthermore, two of the three variables obtained from the SEBT, specifically the cumulated reach distance calculated for both legs and for the dominant leg, and both indices determined in the MFT S3-Check revealed an interaction between the training and the group effect on the dependent variables (Table I). These interaction effects suggested a larger improvement of postural control in the SLT group than in the F-STAB group (Figure 2). However, in a separate direct comparison of the group results after training, only MFT S3-Check indices were significantly different between the SLT and F-STAB groups (Table I, column 11).

Discussion

The main result of the current study was that all subjects showed a substantial and significant improvement in all the variables characterizing different forms of postural control. Furthermore, in four variables, specifically in both MFT S3-Check variables and in two of three cumulated SEBT excursion distances, the results indicated that participants training on the slack line improved more than the participants in the FIFA 11+ programme. Overall, these results suggest that 12 units of slackline training led to
Could slackline training complement the FIFA 11+ programme regarding training of neuromuscular control?

Table I. Statistical results of the slackline training group (SLT) and stabilization training group (F-STAB) for all tests before (pre) and after (post) the training. Significant *-values are printed in bold letters.

| Training effect (pre-post test) | Interaction group × training | Group difference | Value | Power |
|--------------------------------|------------------------------|------------------|-------|-------|
|                              | Interaction effect           |                  |       |       |
|                              | Value                         |                  |       |       |
| Star excursion balance test [cm] |                              |                  |       |       |
| Mean both legs                | $F_{1, 23} = 10.91$           | 0.003            | $f = 3.161$ | 0.999 |
| Dominant                      | $F_{1, 23} = 6.733$           | 0.016            | $f = 2.937$ | 0.999 |
| Non-dominant                  | $F_{1, 23} = 0.616$           | 0.440            | $d = 1.233$ | 0.999 |
| Z                             | $Z_{0.25} = 3.89$             | 0.001            | $Z_{0.25} = 3.89$ | 0.001 |
| Dominant                      | $Z_{0.25} = 3.89$             | 0.001            | $Z_{0.25} = 3.89$ | 0.001 |
| Non-dominant                  | $Z_{0.25} = 3.89$             | 0.001            | $Z_{0.25} = 3.89$ | 0.001 |
| Closed-eye single-leg stand [sec] |                              |                  |       |       |
| Mean both legs                | $Z_{0.25} = 3.89$             | 0.001            | $Z_{0.25} = 3.89$ | 0.001 |
| Dominant                      | $Z_{0.25} = 3.89$             | 0.001            | $Z_{0.25} = 3.89$ | 0.001 |
| Non-dominant                  | $Z_{0.25} = 3.89$             | 0.001            | $Z_{0.25} = 3.89$ | 0.001 |

Table continued...

Improvements in postural stability resulting from common stabilization exercises as included in the FIFA 11+ programme may be explained by mechanisms of sensorimotor training focusing on joint stabilization and neuromuscular control. Risberg and colleagues defined sensorimotor training as “training enhancing unconscious motor responses by stimulating both afferent signals and central mechanisms responsible for dynamic joint control” (Risberg, Mørk, Jenssen, & Holm, 2001). Both, the FIFA 11+ programme and slackline training incorporate exercises that seem to lead to similar adaptations in the sensorimotor control system. For example, improved force development (Granacher et al., 2010), a reduced H-reflex (Keller et al., 2012), and changes in anticipatory muscle activation (Pfusterschmied, Stöggli, et al., 2013) are some effects of slackline training also found in response to common balance training. Multifaceted neural adaptations are associated with balance training (Taube, Gruber, & Gollhofer, 2008) and specifically supraspinal adaptations have been associated with improved balance performance (Taube et al., 2007). It seems plausible that supraspinal rather than spinal reflex mechanisms are more relevant to prevent injury-prone situations (Gollhofer, Granacher, Taube, Melnyk, & Gruber, 2006); however, to the best of our knowledge, direct investigations into what neural mechanisms may play an important role in injury prevention is still lacking.

The current study concentrated only on the balance and stabilization exercises of the FIFA 11+ warm-up programme, complemented by a few additional exercises. Our results suggest that the training of neuromuscular control was, in the current study, more intense compared to the standard 11+ programme. For example, Steffen and colleagues also reported improvements in the SEBT reach distances, but, contrary to our results, found no significant results for the single-leg stance (Steffen, Emery, et al., 2013). Impellizzeri and colleagues reported improved flexor strength, but found only non-significant improvements in the SEBT reach distance (Impellizzeri et al., 2013). The most likely explanation for these discrepancies is that, in our study, the training took place 3 times per week and the full 20 minutes were dedicated to balance and sensorimotor training, whereas the FIFA 11+ exercises are typically conducted once or twice per week (Steffen, Emery, et al., 2013). The current study, thus, compared the effects of slackline training with – in terms of balance and postural control training – a particularly effective version of the 11+ programme.

Recent research into the specificity of balance training (Giboin, Gruber, & Kramer, 2015;
Naumann, Kindermann, Joch, Munzert, & Reiser, 2015) suggests limited transferability of trained balance skills between different postural tasks (Kümmel, Kramer, Giboin, & Gruber, 2016). This aspect is highly relevant for injury prevention programmes, such as FIFA 11+, yet rarely taken into consideration. We speculate that slacklining, since it represents a multifaceted whole-body exercise requiring the alignment and coordination of all body segments in multifaceted variations, may represent a form of postural control training that provides better transferability of acquired sensorimotor skills than more specialized balance exercises (Pfusterschmied, Lindinger, et al., 2013). However, more research is needed to substantiate this speculation: on the one hand, a recent meta-analysis reported small-to-medium transfer effects (Donath et al., 2016), leading the authors to recommend embedding slackline training into a multimodal training programme. On the other hand, there are results suggesting that slackline training did improve postural control during simulated slips (Pfusterschmied, Stöggel, et al., 2013), which would suggest that slackline training does have an injury preventive effect.

Figure 2. Results of the pre- and post-training balance tests: star excursion balance test (a); Closed-eye, single-leg stance on a balance pad (b); MFT S3-Check (c).
The limitations of the current study include that the present sample contained mainly sport students, not specifically soccer players. However, all volunteers were physically fit and regularly practised sports. We therefore believe that our results are likely transferrable to non-professional soccer players. Furthermore, the 11 + programme is not exclusively applied in soccer, but has, in fact, already been successfully applied in other sports (Longo et al., 2012). Another limitation is that the two sexes were not equally represented within the individual test groups; however, this imbalance was similar in both groups. Regarding the training programme, it was attempted to avoid exercises in the training programme of both groups which are used in the pre- and post-tests to minimize direct learning effects. However, it is hardly possible to avoid the single-leg stance in both slackline training and balance training. Therefore, it cannot be excluded that the improvement of the closed-eye single-leg stance can partly be attributed to a direct learning effect.

No implications for injury prevention can be deduced from the current study. However, if improved balance and neuromuscular control is one of the underlying mechanisms that make the FIFA 11+ warm-up effective, then it seems plausible to hypothesize that slacklining might also lead to reduced injury rates. Further research into potential preventive effects of slackline training – and also into potential detrimental effects or injury risks – is therefore warranted and necessary.

Conclusions

The results of the present study suggest that slackline training offers similar – or better – improvements in balance and neuromuscular control as the FIFA 11+ warm-up programme. If compliance with the FIFA 11+ programme is declining, then slacklining might offer an alternative approach to reach the training goals of improved balance and sensorimotor control.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

PETER A. FEDEROLF http://orcid.org/0000-0002-0266-6813

References

Birmingham, T. B. (2000). Test-retest reliability of lower extremity functional instability measures. Clinical Journal of Sport Medicine, 10(4), 264–268.
randomized controlled trial. *The American Journal of Sports Medicine*, 40(5), 996–1005.

Mandelbaum, B. R., Silvers, H. J., Watanabe, D. S., Knarr, J. F., Thomas, S. D., Griffin, L. Y., … Garrett, W. (2005). Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes 2-year follow-up. *The American Journal of Sports Medicine*, 33(7), 1003–1010.

McGuine, T. A., Greene, J. J., Best, T., & Leveson, G. (2000). Balance as a predictor of ankle injuries in high school basketball players. *Clinical Journal of Sport Medicine*, 10(4), 239–244.

Munro, A. G., & Herrington, L. C. (2010). Between-session reliability of the star excursion balance test. *Physical Therapy in Sport*, 11(4), 128–132.

Naumann, T., Kindermann, S., Joch, M., Munzert, J., & Reiser, M. (2015). No transfer between conditions in balance training regimes relying on tasks with different postural demands: Specificity effects of two different serious games. *Gait & Posture*, 41(3), 774–779.

O’Brien, J., Young, W., & Finch, C. F. (2017). The delivery of injury prevention exercise programmes in professional youth soccer: Comparison to the FIFA 11+. *Journal of Science and Medicine in Sport*, 20(1), 26–31. doi:10.1016/j.jsams.2016.05.007

Olsen, O.-E., Myklebust, G., Engebretsen, L., Holme, I., & Bahr, R. (2005). Exercises to prevent lower limb injuries in youth sports: Cluster randomised controlled trial. *British Medical Journal*, 330(7489), 449.

Owoeye, O., Akinbo, S., Tella, B. A., & Olawale, O. A. (2014). Efficacy of the FIFA 11+ warm-up programme in male youth football: A cluster randomised controlled trial. *Journal of Sports Science and Medicine*, 13(2), 321–328.

Pfusterschmied, J., Buchecker, M., Keller, M., Wagner, H., Taube, W., & Müller, E. (2013). Supervised slackline training improves postural stability. *European Journal of Sport Science*, 13(1), 49–57.

Pfusterschmied, J., Lindinger, S., Buchecker, M., Stöggli, T., Wagner, H., & Müller, E. (2013). Effect of instability training equipment on lower limb kinematics and muscle activity. *Sportverletzung· Sportschaden*, 27(01), 28–33.

Pfusterschmied, J., Stöggli, T., Buchecker, M., Lindinger, S., Wagner, H., & Müller, E. (2013). Effects of 4-week slackline training on lower limb joint motion and muscle activation. *Journal of Science and Medicine in Sport*, 16(6), 562–566.

Plisky, P. J., Rauh, M. J., Kaminski, T. W., & Underwood, F. B. (2006). Star excursion balance test as a predictor of lower extremity injury in high school basketball players. *Journal of Orthopaedic & Sports Physical Therapy*, 36(12), 911–919.

Raschner, C., Lembert, S., Platzer, H., Patterson, C., Hilden, T., & Lutz, M. (2008). S3-Check-Evaluierung und Normwerteerhebung eines Tests zur Erfassung der Gleichgewichtsfähigkeit und Körperstabilität. *Sportverletzungsprävention & Sportschaden*, 22(2), 100–105.

Risberg, M. A., Mork, M., Jenssen, H. K., & Holm, I. (2001). Design and implementation of a neuromuscular training program following anterior cruciate ligament reconstruction. *Journal of Orthopaedic & Sports Physical Therapy*, 31(11), 620–631.

Rössler, R., Donath, L., Bizzini, M., & Faude, O. (2016). A new injury prevention programme for children’s football—FIFA 11+ Kids—can improve motor performance: A cluster-randomised controlled trial. *Journal of Sports Sciences*, 34(6), 549–556.

Silvers-Granelli, H., Mandelbaum, B., Adeniji, O., Insler, S., Bizzini, M., Pohlig, R., … Dvorak, J. (2015). Efficacy of the FIFA 11+ injury prevention program in the collegiate male soccer player. *The American Journal of Sports Medicine*. doi:10.3978/j.issn.0363-5465.2015.02.2469

Soligard, T., Myklebust, G., Steffen, K., Holme, I., Silvers, H., Bizzini, M., … Andersen, T. E. (2008). Comprehensive warm-up programme to prevent injuries in young female footballers: Cluster randomised controlled trial. *British Medical Journal*, 337, a2469.

Soligard, T., Nilstad, A., Steffen, K., Myklebust, G., Holme, I., Dvorak, J., … Andersen, T. E. (2010). Compliance with a comprehensive warm-up programme to prevent injuries in youth football. *British Journal of Sports Medicine*, 44(11), 787–793.

Steffen, K., Emery, C. A., Romiti, M., Kang, J., Bizzini, M., Dvorak, J., … Meeuwisse, W. H. (2013). 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 controlled trial. *British Journal of Sports Medicine*, 47(12), 794–802.

Steffen, K., Meeuwisse, W. H., Romiti, M., Kang, J., McKay, C., Bizzini, M., … Emery, C. A. (2013). Evaluation of how different implementation strategies of an injury prevention programme (FIFA 11+) impact team adherence and injury risk in Canadian female youth football players: a cluster-randomised trial. *British Journal of Sports Medicine*. doi:10.1136/bjsports-2012-091887

Taube, W., Gruber, M., Beck, S., Faist, M., Gollhofer, A., & Schubert, M. (2007). Cortical and spinal adaptations induced by balance training: Correlation between stance stability and corticospinal activation. *Acta Physiologica*, 189(4), 347–358.

Taube, W., Gruber, M., & Gollhofer, A. (2008). Spinal and supraspinal adaptations associated with balance training and their functional relevance. *Acta Physiologica*, 193(2), 101–116.