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EXERCISE PHYSIOLOGY

The Effect of an Intentional Functional Movement Warm-Up on Ninth Graders' Movement Quality

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Abstract

Dysfunctional movement, a suggested contributing factor for musculoskeletal pain and injury, appears to increase as adolescents experience puberty. This study investigated dysfunctional movement among a group of ninth-grade physical education students to determine if a standardized functional movement warm-up (FMWU) would improve movement quality more than a regular physical education warm-up. The FMWU group (n = 22) completed the assigned warm-up 3 times/week over 9 weeks, whereas the regular warm-up (RWU) group (n = 22) completed a regular dynamic warm-up. The Functional Movement Screen (FMS) was used in the assessment of movement quality pre and post. The FMS total composite mean score was 12.20 (SD = 1.56). Additionally, 45.5% of participants had at least one asymmetry and 93.2% scored a 1 on at least one FMS task. There was a significant Group × Time interaction, F(1, 42) = 11.27, p = .002. The FMWU group significantly improved for the total composite score, deep squat (DS), rotatory stability, and scores of 1. All other measures of movement trended positively for the FMWU group except the in-line lunge (ILL), which remained the same. The RWU group slightly

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or significantly worsened in the DS, ILL, active straight leg raise, and hurdle step, and the total composite score did not change. The findings of this study suggest there is a high rate of dysfunctional movement among ninth-grade adolescents and an intentionally designed FMWU is an efficient method of addressing movement quality in physical education.

Adolescents with musculoskeletal pain experience behavioral, physical, and psychological consequences and they are more likely to become one of the 160 million American adults who suffer from pain. Adolescents report being absent from school, a decrease in physical activity, and a lower health-related quality of life due to musculoskeletal pain (Jones et al., 2004; O'Sullivan et al., 2012).

Deficits in functional movement patterns have been suggested as a contributing factor to musculoskeletal pain and injury (Brown et al., 2008; Campbell & Muncer, 2005; Powers, 2003). Individuals can develop restrictions in joint mobility (i.e., production of movement) and stability (i.e., steadiness while resisting excessive motion), resulting in a change of coordinated movement. The adaptive movement patterns (i.e., dysfunctional movement) a person uses to overcome restrictions in mobility and/or stability can create undue stress on body structures, resulting in pain, inflammation, and injury (Comerford & Mottram, 2001a, 2001b; Cook, 2010; Powers, 2003).

After the onset of puberty, musculoskeletal pain and injury can dramatically increase, whereas quality functional movement appears to decline (Kamper et al., 2016; Wild et al., 2016). Injury can be a consequence of a decline in movement quality (Hewett et al., 2005; Omi et al., 2018; Ridder et al., 2017; Zazulak et al., 2007).

Overall, adolescent movement quality scores are low, with raw mean scores of 14 or less on the Functional Movement Screen (FMS; Lester et al., 2017; Liao et al., 2017). For example, a score of ≤ 14 is a potential threshold of injury for professional football players (Kiesel et al., 2007). Adolescents in general, though, may have a lower normal score due to their age and physical maturity. The reported total mean score for an active adult population is 15.7 (Schneiders et al., 2011), whereas the reported total FMS score for a regularly active adolescent population is 14.59 (Abraham et al., 2015). However, even with the lower normative value for active adolescents, some total FMS scores in the general adolescent populations are concernedly low, falling below 14.59 (Duncan et al., 2013; Lester et al., 2017). Additionally, when there is greater than 50% of adolescents present with at least one asymmetry, this can further stress the kinetic chain (Coker, 2018; Mitchell et al., 2015).

Interventions that improve movement quality, as measured by FMS, have been widely researched in the athletic and physical labor force (e.g., firefighters, military) populations. Improvement in FMS total composite scores and reduction of asymmetries have been demonstrated in various populations such as football players, MMA fighters, and firefighters after 4 to 8 weeks of programming (Bodden et al., 2015; Kiesel et al., 2011; Stanek et al., 2017). Published studies investigating the effect of interventions on the general early to mid-adolescent population have been limited and have had mixed findings. While Coker (2018) and McFelea et al. (2010) found marked improvement of FMS scores for boys only, Wright et al. (2015) did not find significant improvement in the total composite score of participants. Thus, further investigation could further understanding of how FMS scores can be enhanced. Therefore, this study investigated dysfunctional movement among a group of ninth-grade physical education students to determine if a standardized functional movement warm-up (FMWU) would improve movement quality more than a regular physical education warm-up. We hypothesized that the FMWU would improve movement quality more than just participation in regular physical education in the general early to mid-adolescent population.

Method

This study used a convenience sample to gather information about the functional movement quality of adolescents in ninth-grade physical education. Participants' movement quality was assessed with the Functional Movement Screen (FMS) at the beginning of the school year and again 9 weeks later. For the 9 weeks, the intervention group completed a standardized functional movement warm-up (FMWU), whereas the control group completed their regular dynamic warm-up at the beginning of their physical education classes.

Participants

Ninth-grade students (aged 13–15) were recruited from a Midwestern public high school. After Institutional Review Board

(IRB) approval, parental consent was collected before the start of school. Students with parental consent were randomly assigned to Class A (35 students) or Class B (36 students) by the physical education department. Fifty-six of the eligible ninth-grade students (30 female, 23 male) assented to the study. Class A was assigned as the FMWU group and Class B as the regular warm-up (RWU) group. Exclusion criteria included a musculoskeletal injury that prevented physical education participation at the start of the study or pain while performing any FMS tasks. None of the participants met the exclusion criteria at pretesting. However, there was some attrition of participants due to moving of schools, being absent on testing days, or not completing every FMS task during posttesting. Forty-four of the 56 participants completed pre- and posttesting. There was also one teacher included in the study. The teacher led the FMWU.

Procedure

All ninth-grade physical education participants' movement quality was screened at the beginning of the school year with the FMS and again 9 weeks later. The FMWU completed the intervention 3 times/week (Monday, Wednesday, Friday), except for one week when the warm-up was only completed once due to school vacation (i.e., fall break). There were 25 total sessions. After participants were acclimated with the exercises, the warm-up was completed at the start of class in approximately 9 min. The RWU group participated in their normal dynamic warm-up for the 25 sessions. After completing their respective warm-ups at the beginning of class, all participants partook in their regular physical education activities for the day.

The lead researcher facilitated FMS testing and two raters independently scored the FMS via video. This ensured reliability of the ratings. Video scoring has been shown to be an effective method for inter- and intrarater reliability and even novice raters have been shown capable of scoring the simple tests effectively (McCunn et al., 2016; Minick et al., 2010). The FMS consists of seven tasks: deep squat (DS), in-line lunge (ILL), hurdle step (HS), active straight-leg raise (ASLR), trunk stability push-up (TSPU), rotary stability (RS), and shoulder mobility (SM; Cook, 2010). The seven movement patterns are each scored in value from 0 to 3, with a score of 3 being awarded when the movement pattern is completed with no physical compensations. A score of 2 is awarded for completion of the movement pattern, but some deviation in the movement pattern is present. A score of 2 is still considered a satisfactory score. A score of 1 is awarded if the individual is not able to complete the movement pattern. A score of 0 is given if pain is present. The individual scores are added together for a total composite score out of 21. Additionally, there are three clearing tests for the shoulder and back that are simply scored as a plus (pain present) or minus (no pain; Cook et al., 2014b). Collected demographic and background information included age, gender, height, weight, participation in an organized sport, significant injury history, and physical activity. The Physical Activity Questionnaire for Adolescents (PAQ-A) was used in the assessment of physical activity (Kowalski et al., 2004).

The teacher of the FMWU group led the warm-up for 9 weeks, being provided written instructions and trained on how to lead the FMWU. The FMWU includes exercises to address ankle mobility (i.e., dorsiflexion), leg stability and mobility (i.e., hip mobility and weak and/or inactive gluteal muscles), thoracic spine mobility, shoulder mobility and stability, and trunk stability (i.e., weak and/or inactive core muscles). These issues are often reported in clinical practice when performance on FMS tasks results in a score of less than 3 (Cook et al., 2014a, 2014b). The lead researcher developed the FMWU and two board-certified physical therapists reviewed it. Table 1 shows the warm-up. The RWU group, led by a different teacher, completed their normal warm-up activities (i.e., jog and dynamic warm-up) each day. Postintervention, all participants were retested with the FMS, with the same protocol as the pretesting.

Table 1
Functional Movement Warm-up

Exercise	Description
Jog	Across court and back keeping hip, knee, and ankle aligned.
Shuffle	Across court and back keeping hip, knee, and ankle aligned.
Backpedal	Across court and back landing on toes and keeping knees bent slightly.

Table 1 (cont.)

Exercise	Description
Forward/backward hops	While maintaining slight bend in knees and keeping hip, knee, and ankle aligned, jump forward 3 times and backward 3 times.
Lateral hops	While maintaining slight bend in knees and keeping hip, knee, and ankle aligned, jump left 3 times and right 3 times.
Forward run 3-step deceleration	Across court and back without extending lead leg knee beyond toe on stop.
Walking lunges	Across court keeping hip, knee, and ankle aligned.
Low bear crawl	Across court, using reciprocal pattern and keeping knees only slightly off floor, maintain a flat back.
Bird dogs	While in a quadruped position, raise opposite arm and leg for 3 seconds for 3 repetitions and repeat for other side.
Bridge	Hold 3 seconds for 3 repetitions while laying supine on the floor, hips to the ceiling with knees flexed beyond 90 degrees.
Thoracic spine rotation with reach	Rotate torso with bottom arm reaching for the ceiling with top knee flexed at 90 degrees. From this position, take 5 deep breaths then repeat on other side.
Inchworm with push-up plus	3 repetitions of bending forward and walking hands out slowly, when in a push-up position push upper back toward the ceiling and hold for 3 seconds, then walk feet to hands and begin next repetition.
Single leg RDL with knee raise	Bend at hips and extending 1 leg behind body while lowering torso, extending arms back, palms up and keeping back flat, then return to standing position on 1 leg and bring knee up toward torso. Repeat 3 times for each leg.

Table 1 (cont.)

Exercise	Description
Deep (low) squat with calf stretch	With feet shoulder width apart, lower bottom to ground, attempting to keep heels flat, hold for 3 seconds, then walk out hands to downward dog position, eliciting stretch in hamstrings and calves, hold for 3 seconds, then bend knees, hold for 3 seconds, then push back into low squat. Complete 3 full repetitions.
Overhead squat	With arms at sides, palms facing body ,and thumbs up, flex straight arms to form a Y with the body while squatting to as close to parallel as possible, hold for 3 seconds. Complete 3 repetitions.

Note. For a complete description, contact the lead researcher.

Data Analysis

The FMS total composite mean score, individual tasks scores, asymmetries, and scores of 1 for all participants were reported with descriptive statistics. Whether a standardized FMWU in physical education improves movement quality more than a regular physical education warm-up was determined through a mixed-design (Group × Time) analysis of variance (ANOVA) for the total composite score. Paired-sample *t* tests were completed for within differences of all movement quality measures.

Results

Forty-four participants (19 male, 25 female) with a mean age of 14.25 (SD = 0.49) completed pre- and post-FMS testing. Table 2 shows the descriptive statics. The FMS total composite score of all participants was 12.20 (SD = 1.56). Scores ranged from 9 to 15, with 95.5% scoring ≤ 14, 56.8% scoring ≤ 12, and 22.8% scoring ≤ 10. The SM and ASLR were the highest of the seven FMS tasks, with 79.6% and 81.8% participants, respectively, scoring a 2 or 3. The DS and TSPU were the lowest of FMS scores, with 65.9% and 77.3% of participants, respectively, scoring a 1. Additionally, 45.5% of participants had at least one asymmetry; 93.2% scored a 1 on at least one

Table 2
Baseline Descriptive Statistics of All Participants

Descriptive	*N*	Range	*M*	*SD*
Total composite	44	9.00–15.00	12.20	1.56
SM	44	1.00–3.00	2.39	.81
HS	44	1.00–2.00	1.91	.29
DS	44	1.00–2.00	1.34	.48
ILL	44	1.00–2.00	1.80	.41
ASLR	44	1.00–3.00	1.98	.59
RS	44	1.00–2.00	1.59	.50
TSPU	44	1.00–2.00	1.22	.42
Asymmetries	44	0.00–3.00	.84	.78
Scores of 1	44	0.00–5.00	2.55	1.35

Note. SM = shoulder mobility; HS = hurdle step; DS = deep squat; ILL = inline lunge; ASLR = active straight leg raise; RS = rotary stability; TSPU = trunk stability push-up.

FMS task, 77.3% scored a 1 on two or more FMS tasks, and 27.3% scored a 1 on four or five FMS tasks.

Independent-samples *t* tests were used in the calculation of any differences between groups for numerical data and Fisher's Exact Test was used for categorical data at the start of the study. There were no significant differences between the groups in pre-FMS total composite scores, asymmetries, scores of 1, injury history, sports participation, physical activity levels, and overweight/obesity ($p > .05$).

A mixed-design (Group × Time) ANOVA on the total composite scores revealed a significant Group × Time interaction, $F(1, 42) = 11.27$, $p = .002$. Paired-samples *t* tests were used in the comparison of FMS total composite scores and individual FMS tasks scores pre versus post (Table 3). The paired-samples *t* tests revealed a significant increase from the pretest composite score ($M = 11.95$) to the posttest composite score ($M = 13.13$) for the FMWU group, $t(21) = -3.954$, $p = .001$, and no difference for the total composite score ($M = 12.45$ both pre and post) of the RWU group, $t(21) = .000$, $p = 1.00$. The paired-samples *t* test for individual FMS tasks scores found the FMWU group significantly improved in DS ($p = .011$) and RS ($p = .021$), whereas the RWU group did not significantly improve for any task and the ASLR significantly declined ($p = .04$). Paired-samples t tests were also conducted for the comparison within groups pre versus post asymmetries and scores of 1, which denote dysfunction. There was no significant difference in asymmetries from pre to post for the FMWU group, $t(21) = 1.821$, $p = .08$, or the RWU group, $t(21) = 1.096$, $p = .29$. Scores of 1 significantly declined from pre to post in the FMWU group, $t(21) = 3.846$, $p = .001$. No significant difference was found in scores of 1 from pre to post in the RWU group, $t(21) = -.439$, $p = .67$.

Table 3

Means and Standard Deviations for the RWU and FMWU Group

	RWU group (*n* = 22)		**FMWU group (*n* =22)**	
	Pretest	**Posttest**	**Pretest**	**Posttest**
Total composite	12.45 ± 1.71	12.45 ± 1.74	11.95 ± 1.40	13.13 ± 1.75*†
SM	2.64 ± 0.66	2.86 ± 0.35	2.14 ± 0.89	2.36 ± 0.73
HS	1.95 ± 0.21	1.95 ± 0.21	1.86 ± 0.35	1.95 ± 0.21
DS	1.22 ± 0.43	1.14 ± 0.35	1.45 ± 0.51	1.72 ± 0.46*†
ILL	1.77 ± 0.43	1.68 ± 0.48	1.82 ± 0.39	1.82 ± 0.39
ASLR	2.05 ± 0.72	1.85 ± 0.71**‡	1.91 ± .43	2.05 ± 0.72
RS	1.59 ± 0.50	1.64 ± 0.49	1.59 ± 0.50	1.82 ± 0.39*†
TSPU	1.22 ± 0.43	1.32 ± 0.57	1.22 ± 0.43	1.41 ± 0.59
Asymmetries	0.77 ± 0.81	0.55 ± 0.74	0.91 ± 0.75	0.64 ± 0.73
Scores of 1	2.50 ± 1.50	2.59 ± 1.50	2.59 ± 1.22	1.68 ± 1.09**†

Note. RWU = regular warm-up; FMWU = functional movement warm-up; SM = shoulder mobility; HS = hurdle step; DS = deep squat; ILL = inline lunge; ASLR = active straight leg raise; RS = rotary stability TSPU = trunk stability push-up.

*significant increase at $p < .05$. **significant decrease at $p < .05$.

† positive change. ‡ negative change.

Discussion

This study investigated dysfunctional movement among a group of ninth-grade physical education students to determine if a standardized FMWU would improve movement quality more than a regular physical education warm-up. We hypothesized that the FMWU would improve movement quality more than just participation in regular physical education in the general early to mid-adolescent population. The results of this research indicate that dysfunctional movement is prominent among ninth-grade physical education students. The baseline total composite score of all participants was 12.20 (*SD* = 1.56), which is considered low (Kiesel et al., 2007). This is consistent with other research that has found low FMS composite scores (≤ 14) in the general adolescent population (Lester et al., 2017; Liao et al., 2017). The total composite score in this research is even lower than the 14.05 (± 2.48) in Lester et al. (2017) for a group with a similar mean age (12–16, *M* = 14.42, *SD* = 0.98). The low composite scores in this study appear to be largely due to poor performance in the TSPU, DS, and RS, as well as the high rate of scores of 1. Overall, 93.2% of participants scored a 1 on at least one FMS task, and 77.3% of participants scored a 1 on two or more FMS tests. The TSPU (77.3%), DS (65.9%), and RS (40.9%) had the highest percentage of participants receiving a score of 1, with no participants scoring a 3 at baseline. The TSPU having the lowest mean score in the adolescent population is consistent with other research (Abraham et al., 2015; Lester et al., 2017) and is not surprising considering the need for upper body strength along with core activation. The DS (second lowest) and RS (third lowest) scores are the same as in Mitchell et al. (2015) in 8- to 11-years-old, but contradicts Abraham et al.'s (2015) finding of the DS being the second-highest FMS task in those 10 to 17 years old.

Interestingly, the total composite score and scores of 1 in this study are worse than in previous research; however, the number of asymmetries is slightly better. The rate of participants with at least one asymmetry in this study (45.5%) is lower than the 63.8% in Mitchell et al. (2015) and 51% in Coker (2018), although caution is warranted in comparisons of adolescent FMS scores across research due to varied samples (i.e., size and age groups) and the maturational stage of participants. Even though participants may be of similar chronological age, their point in maturation may vary. FMS tests that require a higher rate of strength and stability are typically performed better later in maturation (Wright & Chesterton, 2019), and the decrease in being able to maintain the three points of contact (head, upper back, and tailbone) with the dowel during the ILL may be due to decrease of thoracic spine mobility with an increase in age (Lester et al., 2017). For research with pubescent adolescents, consideration of maturational stage, even though participants are of similar age, may be necessary. Nevertheless, the low total composite score, along with the rates of asymmetries and scores of 1 demonstrate a high rate of dysfunctional movement, which may lead to musculoskeletal pain and injury. The plethora of scores of 1 is most concerning since a score of 1 indicates the participant could not perform the movement, and intervention is recommended.

The findings of this study suggest the FMWU is an intervention that improves movement quality of ninth-grade physical education students and does so more than a regular physical education warm-up. These findings are consistent with Coker's (2018) study of a different functional warm-up that includes the use of exercise bands with seventh- and eighth-grade physical education students over 6 weeks. In the current study, the FMWU group demonstrated slight or significant improvement in all measures of movement in this study except the ILL, which remained the same. The RWU group slightly or significantly worsened in three of the FMS tests (DS, ILL, ASLR), slightly improved in three tests (SM, RS, TSPU), and did not change in HS and total composite score. Even though the RWU group performed a dynamic warm-up on most days that the FMWU group completed the FMWU, the intentionality of exercise selection may explain the differences in improvement. The FMWU was designed to improve movement. Exercises for the FMWU were selected with consideration of previous research and expert opinion for high-impact movements. Intentionally focusing the warm-up to address mobility and stability in areas of the body that are commonly reported as issues in clinical practice, instead of approaching it as only a way to prepare for the main activity for the day, may be beneficial.

There are limitations to acknowledge. Even though information was collected regarding injury history, BMI, physical activity level, and sport participation, and no significant differences between the two groups were observed, the generalizability of the results is limited due to the small sample size. Additionally, it is unclear which exercises and/or combination in the FMWU contribute to improvement. It is unknown if exercise substitutions will have the same effect. Future research with larger sample sizes and consideration of how to discern the effect of individual exercises/combination is suggested.

This research provides evidence that ninth graders have a high rate of dysfunctional movement and an intentionally designed standardized, physical education warm-up can improve movement quality. The FMWU is not only time effective (less than 10 min) in addressing dysfunctional movement in physical education but also cost effective. To our knowledge, this is the first research demonstrating an effective FMWU in physical education that does not require any equipment. Including warm-ups, such as the one designed for this study, in physical education is a practical way for physical educators to combat dysfunctional movement that may affect students' ability to be healthy, lifelong movers.

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