BUTLER-STORSVED, LYNDA, Ed.D. Approaching Adolescent Movement Quality in Physical Education. (2020)
Directed by Dr. Pam Brown. 70 pp.

Musculoskeletal pain and injury experienced by adolescents leads to behavioral, physical, and psychological consequences. Adolescents with recurrent pain are also more likely to carry these issues into adulthood. Dysfunctional movement, a suggested contributing factor, appears to increase as adolescents experience puberty. The purpose of this study was to investigate dysfunctional movement among a group of 9th-grade physical education students and to determine if a standardized, functional movement warm-up (FMWU) would improve movement quality more than regular physical education. Forty-four 9th-grade students were randomly assigned to a FMWU group (n = 22) and a regular warm-up (RWU) group (n = 22). The FMWU group completed the assigned warm-up 3 times per week over the course of 9 weeks except for one week only including one session, for a total of 25 total sessions. The Functional Movement Screen (FMS) was used to assess movement quality pre and post. Additionally, the lead researcher took notes of observed dysfunction while scoring FMS tasks. FMWU participant perceptions were collected by survey and the teacher's perceptions were collected through a semi-structured interview.

The results indicate a high rate of dysfunction among the group of ninth-grade participants. The total composite FMS 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. A mixed-design (Group x Time) analysis of variance (ANOVA) on the total composite scores revealed a significant group by time interaction, F (1, 42) = 11.27, p = .002. Paired samples t-tests for the FMWU group revealed significant improvement for the total composite score, deep squat (DS), rotatory stability (RS), and scores of 1. All other measures of movement trended positively for the

FMWU group except the inline lunge (ILL), which remained the same. Whereas, the RWU group slightly or significantly worsened in the DS, ILL, and active straight leg raise (ASLR), and the hurdle step (HS) and total composite score did not change. Observations support the effect of the FMWU and 60% of FMWU participants reported liking the warm-up.

The findings of this study suggest there is a high rate of dysfunctional movement among 9th-grade adolescents and an intentionally designed FMWU is an efficient way to address movement quality in physical education.

APPROACHING ADOLESCENT MOVEMENT QUALITY

IN PHYSICAL EDUCATION

by

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A Dissertation Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Greensboro
2020

Approved by

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APPROVAL PAGE

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CHAPTER I

PROJECT OVERVIEW

Adolescents with musculoskeletal pain are more likely to become one of the 160 million adult Americans who suffer from pain, which in turn costs the United States $562-635 billion each year (Institute of Medicine (US) Committee on Advancing Pain Research, Care, and Education, 2011; Kamper, Henschke, Hestbaek, Dunn, & Williams, 2016). Additional to the financial burden, musculoskeletal pain contributes to behavioral, physical, and psychological consequences for adults and adolescents. Musculoskeletal pain results in adolescents being absent from school, a decrease in physical activity, and a lower health-related quality of life (Jones, Stratton, Reilly, & Unnithan, 2004; O'Sullivan, Beales, Smith, & Straker, 2012).

Following the onset of puberty, musculoskeletal pain and injury dramatically increase, while quality functional movement appears to decline (Kamper, Yamato, & Williams, 2016; Wild, Munro, & Steele, 2016). Functional movement allows the body to move with proper mechanics when performing basic movement patterns (e.g., squatting, lunging). 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) used 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). As adolescents progress through puberty, adaptations in movement occur (Wild et al., 2016) and injury can be a resulting consequence (Hewett et al., 2005; Omi et al., 2018; Ridder, Witvrouw, Dolphens, Roosen, & Ginckel, 2017; Zazulak, Hewett, Reeves, Goldberg, & Cholewicki, 2007). Despite

these findings, very little research has focused on using movement screens to measure the movement quality of the general adolescent population. The limited research conducted does suggest adolescents need interventions to improve dysfunction (Fuller et al., 2017; Lester et al., 2017; Liao, Zheng, & Meng, 2017; Parenteau-G et al., 2014). Given interventions to improve movement quality have been successful and thoroughly studied in athletic and physical labor force (e.g., firefighters, military) populations (Bodden, Needham, & Chockalingam, 2015; Dinc, Kilinc, Bulat, Erten, & Bayraktar, 2017; Kiesel, Plisky, & Butler, 2011; Lee, Zhang, & Lee, 2015), there is promise for interventions to be effective for the general adolescent population. Therefore, there is a need to further investigate adolescent movement quality and to determine interventions to improve movement in professional practice that can reach a large population.

Background Literature

Musculoskeletal pain has grown exponentially since the mid-1990s and is a global issue for adults and adolescents (Harkness, Macfarlane, Silman, & McBeth, 2005). Musculoskeletal disorders account for three of the top 25 causes of disability worldwide with low back and neck pain ranking number one overall and sixth for adolescents and young adults (Vos et al., 2016). Forty percent of adolescents aged 10-16 have experienced low back pain, and as they age, they run the risk of becoming one of the 80% of adults with back pain (Jones et al., 2004; Rubin, 2007). Unfortunately, due to musculoskeletal pain and injury, adolescents already experience similar consequences as adults, which include interference of physical activity participation, lowered health-related quality of life, and school absenteeism (Jones et al., 2004; O'Sullivan et al., 2012).

Movement Quality Link

Deficits in functional movement patterns have been suggested as a contributing factor to musculoskeletal pain and injury (Brown, Padua, Marshall, & Guskiewicz, 2008; Campbell &

Muncer, 2005; Powers, 2003). Based on the kinetic chain theory, dysfunction within one or more joints can influence conditions in another (Karandikar & Vargas, 2011; Powers, 2003). The body is connected through a series of segments (e.g., pelvis, thigh, foot), and the segments are linked by joints. When force is applied to one segment, the force is transmitted to another (Karandikar & Vargas, 2011). Deficits in stability and mobility alter the sequence of movement, which creates stress within the kinetic chain, and body structures can become traumatized, leading to injury (Comerford & Mottram, 2001a, 2001b). For example, weak hip abductors and lack of mobility of the ankle affects the movement of the tibia and femur. The altered movement of the tibia and femur puts added stress on the knee, resulting in potential injury (Hollman, Kolbeck, Hitchcock, Koverman, & Krause, 2006; Kaufman, Brodine, Shaffer, Johnson, & Cullison, 1999; Powers, 2003). These types of findings are why several researchers have emphasized restoring the functional kinetic chain, rather than just treating a localized area or joint (Beckman & Buchanan, 1995; Geraci & Brown, 2005; Powers, 2003).

Researchers also have stressed the need to focus movement quality efforts on the adolescent population (Duncan & Stanley, 2012; Lester et al., 2017; Liao et al., 2017). Adaptations in adolescents' movement occur as their bodies change due to puberty (Wild et al., 2016). Injury has been linked to these altered movement patterns (Hewett et al., 2005; Omi et al., 2018; Ridder et al., 2017; Zazulak et al., 2007). For example, after beginning puberty, girls exhibit a decrease in knee flexion and an increase in external knee abduction during landing tasks, which has been associated with a greater risk of ACL injury (Hewett et al., 2005; Wild et al., 2016). Additionally, weak posterior hip strength has been shown to increase the likelihood of lateral ankle sprains (Ridder et al., 2017). Since deficits in one area of the kinetic chain have been established to cause issues in another area, employing ways to detect movement issues before a person becomes symptomatic is necessary.

Movement Screen

One of the methods practitioners use to identify dysfunctional movement early is movement screens. Movement screens have been developed to assess a person's ability to produce and control integrated bodily movement (Ennett et al., 2017). The Functional Movement Screen (FMS) is one such assessment tool that has been used in various active populations (Butler et al., 2013; Chalmers et al., 2017; Lisman, O'Connor, Deuster, & Knapik, 2013). FMS was designed to assess movement competency and capacity of an active population that is considered uninjured or not experiencing any symptoms of impairment (e.g., obvious pain). The screen applies the kinetic chain theory with the intent to identify functional limitations, including asymmetries that could potentially lead to issues in the future. The FMS consist of seven tasks (Cook, 2010). The tasks include 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). 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 to produce 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, Burton, Hoogenboom, & Voight, 2014b).

Adolescent Movement Screen Performance

Commonly, reported total FMS scores for adolescents have been considered low, with raw mean scores of 14 or less (Lester et al., 2017; Liao et al., 2017). Kiesel, Plisky, and Voight, (2007) were first to suggest a score ≤ 14 as a potential threshold of injury with their research of

professional football players. 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 Abraham et al., (2015) reported a 14.59 total FMS score for a regularly, active adolescent population. However, even when considering the lower normative value for active adolescents, some studies have found total FMS scores in the general adolescent populations to be concernedly low, falling below 14.59 (Duncan, Stanley, & Leddington Wright, 2013; Lester et al., 2017).

Additionally, some researchers have found greater than 50% of adolescents present with at least one asymmetry, which can further stress the kinetic chain (Coker, 2018; Mitchell, Johnson, & Adamson, 2015). The small number of research studies conducted with the general adolescent population provides limited information about the extent of movement quality by primarily reporting the FMS total composite score, with just a couple reporting asymmetries (see Appendix A). These findings highlight the need to further investigate the extent of dysfunctional movement among adolescents and to begin preliminary work to develop appropriate interventions aimed at restoring movement.

Interventions to Improve Movement Quality

Interventions to 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 a 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, Dodd, Kelly, Wolfe, & Swenson, 2017). Published studies investigating the effect of interventions on the general early to mid-adolescent population are limited. The findings and approach of these studies have been mixed. While Coker (2018) and McFelea, Butler, Kiesel, Plisky, and Elkins (2010)

found marked improvement of FMS scores for boys only, Wright, Portas, Evans, and Weston (2015) did not find significant improvement in the total composite score of participants. The interventions tested have varied in duration, exercises, and settings. Only two published studies have investigated the effect of a physical education warm-up intervention. Both used some form of equipment. Richmond, Kang, Doyle-Baker, Nettel-Aguirre, and Emery (2016) found a decrease in the risk of injury for junior high-level students (grades 7, 8, 9 in Canada) with a 12-week, 15-minute high-intensity neuromuscular warm-up. However, the researchers did not measure movement quality. Coker (2018) did use the FMS when evaluating the effect of a 6-week warm-up intervention with middle school students (grades 7 and 8). Only boys in the intervention group significantly improved overall FMS scores, while the control group's overall score slightly declined. The effectiveness of interventions for the general adolescent population is promising; however, further research is needed. Specifically, remaining gaps center on the extent to which a longer intervention without the use of any equipment may enhance movement quality, student and teacher's perceptions of a functional movement warm-up, and whether the findings from Coker (2019) extend to a different age group (i.e., grade 9). These gaps were addressed with this dissertation.

Setting for Intervention

Physical education appears to be a prime setting to determine and implement intentional programming for functional movement. A large number (64%) of ninth graders participate weekly in physical education (National Physical Activity Plan Alliance, 2016). Also, "the goal of physical education is to develop physically literate individuals who have the knowledge, skills and confidence to enjoy a lifetime of healthful physical activity" (SHAPE America, 2013, p. 1). In order to enjoy a lifetime of healthful physical activity, quality movement is necessary. Functional movement is the foundation for fitness and specific skill-related movements (Cook,

2010). However, the type of functional movement described in this paper is not a focus of the traditional physical education curriculum. Reports of physical education teachers' professional development and the national standards for preparing future physical education teachers do not include instruction specific to functional movement quality (Centers for Disease Control and Prevention, 2014; National Association for Sport and Physical Education., 2009). In other words, functional movement is not currently being addressed, and physical education teachers are not being prepared to implement functional movement instruction. Therefore, the approach used in this study was to investigate the effectiveness of an intervention based on previous research and to gather more information concerning the extent of dysfunctional movement among adolescents. These findings will inform the future development of materials and methods to empower physical educators with the knowledge and skill to help students become lifelong healthy movers.

Purpose and Aims

The purpose of this study was to evaluate the movement quality of ninth-grade physical education students and to determine the effect of a standardized functional movement warm-up.

Specific Aim #1: ***To determine the scope of dysfunctional movement among a group of ninth-grade physical education students***.

Specific Aim #2: ***To determine whether a standardized functional movement warm-up in physical education improves movement quality more than regular physical education.***

Methods

This quasi-experimental 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 then again 9 weeks later. For the 9 weeks, the intervention group completed a standardized, functional movement warm-up (FMWU), whereas the control group participated in

physical education as normal. Perceptions of the FMWU were collected from participants and the teacher leading the warm-up.

Participants

Ninth-grade students (aged 13-15) were recruited from a mid-west, public high school. After Institutional Review Board (IRB) approval, parental consent was collected before the start of school (August 2019). 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, 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 pre-testing. However, there was some attrition of participants due to the moving of schools, being absent on testing days, and not completing every FMS task during post-testing. Forty-four of the 56 participants completed pre and post-testing. There was also one teacher included in the study. The teacher led the FMWU and was interviewed at the end of the 9 weeks.

Procedures

All ninth-grade physical education participants' movement quality was screened at the beginning of the school year in August 2019 with the FMS and again 9 weeks later. The FMWU group completed an intervention (i.e., FMWU) over the 9 weeks. The FMWU was completed three times a week (Monday, Wednesday, Friday), except for one week where 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 in approximately nine minutes. The RWU group participated in regular physical education with their normal warm-up. Perceptions of the FMWU were collected from the FMWU group at the end of the 9 weeks.

Additionally, the perceptions of the physical education teacher leading the FMWU were gathered with a post-interview and bi-weekly check-ins via text messaging.

Pre-intervention. All 56 participants were tested using the FMS. FMS testing was facilitated by the lead researcher and was completed over six class days. The first two days included clearing tests, pre-measures (e.g., hand length) for FMS tasks, demographic/background collection, and the shoulder mobility task. Demographic and background information included age, gender, height, weight, participation in an organized sport, significant injury history, and physical activity (see Appendix B). The Physical Activity Questionnaire for Adolescents (PAQ-A), a 7-day recall instrument used to assess physical activity of ninth through 12th graders (Kowalski, Crocker, & Donen, 2004), was administered at week 3 to assess physical activity over a typical week. Day three through six, the remaining FMS tasks were completed. A script for how to complete each task was read to the participants, and a picture and demonstration was provided before performing the movement. The performance was recorded by two video cameras for scoring later. One camera provided a front view and the other a side view.

Video scoring has been shown to be an effective method for inter- and intra-rater reliability and even novice raters are capable of scoring the simple tests effectively (McCunn, aus der Fünten, Fullagar, McKeown, & Meyer, 2016; Minick et al., 2010). Two raters independently scored each task to ensure reliability of the ratings. Rater one was the lead researcher, who is FMS Level One certified. Rater one also took notes of the type of dysfunction observed that resulted in a score less than a 3. Rater two is a seasoned, certified athletic trainer who has used FMS with athletes for over 10 years. Rater two was blinded. Interrater reliability can be found in Appendix C. In order to minimize error in scoring, for any tasks in which there was initial disagreement, the raters reviewed the performance again together, and a consensus score was determined.

During intervention. 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; see Appendix D). These issues are often reported in clinical practice when performance on FMS tasks results in a score less than 3 (Cook, Burton, Hoogenboom, & Voight , 2014a; Cook et al., 2014b). The FMWU was developed by the lead researcher, who is a National Academy of Sports Medicine *Corrective Exercise Specialist*, National Strength and Condition Association *Certified Strength and Conditioning Specialist*, FMS Level One certified, and a licensed physical education teacher. The lead researcher interviewed seven professionals in the fields of strength and conditioning and physical therapy in preparation for developing the warm-up. The themes from the interviews, along with consideration of corrective exercise coursework, previous research interventions, and research findings of exercises that are effective at activating musculature and improving joint range of motion, were collectively considered. Additionally, the warm-up was reviewed by two board-certified physical therapists.

The teacher of the FMWU group led the warm-up for 9 weeks. The teacher was provided written instructions (see Appendix D) and trained on how to lead the FMWU. The RWU group, led by a different teacher, completed their normal warm-up activities (i.e., jog and dynamic warm-up) each day. The teacher of the FMWU also tracked whether each participant completed the FMWU each day. Bi-weekly the lead researcher sent questions to the teacher via text messaging to garner feedback and perceptions from the teacher. The teacher was prompted to provide information about how things were going, student engagement, and questions and/or concerns.

Post-intervention. All participants were re-tested with the FMS following the same protocol as the pre-testing. Student participant perceptions of the FMWU were collected from the

FMWU group. This included questions (see Appendix B) to collect their perceptions of the effect of the warm-up on their movement and what they liked/disliked about the FMWU. The teacher perceptions were gathered through a semi-structured, face-to-face interview. The interview questions (see Appendix B) included open-ended prompts to gather the teacher's perceptions of students' movement quality and her perceptions of the FMWU (e.g., value, challenges).

Data Analysis

To address Aim 1 of determining the scope of adolescents' dysfunctional movement, descriptive statistics were used to report the FMS total composite mean score, individual tasks scores, asymmetries, and scores of 1 for all participants. Aim 2, to determine whether a standardized functional movement warm-up in physical education improves movement quality more than regular physical education, was analyzed with a mixed-design (Group x Time) analysis of variance (ANOVA) for the total composite score and paired sample *t*-tests were completed for within differences of all movement quality measures. Observational notes were used to help provide additional insights into the FMS findings. Detailed notes of why a 3 was not achieved for tasks were recorded for each participant. The detailed notes were analyzed to identify common themes of dysfunction present during FMS testing. For example, themes for the DS included the dowel not aligned over the feet, toes rotated out, heels elevated, and/or lack of depth. Detailed notes were also recorded when comparing pre- and post-performance. The comparison for each task was labeled equal, score plus, score neg, plus, or neg. Equal meant the score and performance were the same. Score plus meant the score and performance improved. Score neg meant the score and performance worsened. Plus and neg meant performance either improved or worsened, respectively, but not enough to result in a different score from pre-testing. Percentages were calculated for each task. Feedback from the FMWU teacher was collected during a semi-structured interview. The interview was audio-recorded, transcribed, and highlights were pulled

to provide the teacher's perspective. The students' perspectives were collected by survey. The frequencies of responses were recorded, and percentages calculated.

Results

A total of 44 participants (19 male, 25 female) with a mean age of 14.25 (*SD* = 0.49) completed pre and post FMS testing. Descriptive statics are presented in Table 1. 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 FMS task, 77.3% scored a 1 on two or more FMS tasks, and 27.3% scored a 1 on four or five tasks.

Table 1

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 one	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

Independent samples *t*-tests were used to calculate any differences between groups for numerical data and Fisher's Exact Test 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 x Time) analysis of variance (ANOVA) on the total composite scores revealed a significant group by time interaction, F (1, 42) = 11.27, p = .002. Paired-samples t-tests were used to compare FMS total composite scores and individual FMS tasks scores pre vs post (see Table 2). 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 was found 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 did not significantly improve for any task, and the ASLR significantly declined (p = .04). Paired-samples *t*-tests were also conducted to compare within groups pre vs. 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 did significantly decline 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 2

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 one	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 $p < .05$

† denotes positive change, ‡ denotes negative change

Other Results

The lead researcher completed observations of movement quality when viewing the video recordings of FMS testing. Dysfunction (i.e., main issues or unmet criteria) observed for the FMS tasks can be found in Table 3. Observations comparing pre to post performances were also completed. In addition to improvement resulting in a higher FMS score, there were also positive changes in movement noted that were not captured by the FMS. The FMWU group had improvements in the HS, DS, and RS that did not result in a change of FMS scores. Nearly 20% of FMWU participants appeared more stable during the HS with less movement at the hip and knee, but the improvement was not enough to boost their overall HS score. Improvements in movement in the DS included greater depth, less knee valgus, and greater shoulder flexion;

however, 36% of the FMWU participants who improved did not improve enough to change their pre-test score. Forty-six percent of FMWU participants was more stable during the RS task, but only 23% was able to meet higher criteria to improve their FMS score. Equal types of improvement were not observed in the RWU group.

Table 3

Observed Dysfunction During FMS Tasks

FMS Test	Issue/Unmet Criteria*
DS	Dowel not aligned over feet; toes rotated out, heels elevated; lack of depth
HS	Misalignment of hips, knees, and ankles; dowel not parallel; difficulty with balance
ILL	Dowel not vertical and/or in contact with the head, upper back, and tailbone; difficulty with balance
ASLR	Non-moving limb lifting from the board; moving limb bent
TSPU	Inability to lift the body with no lag
RS	Lack of stability when extending arms and legs

Note. * listed in order beginning with most observed; DS = deep squat; HS = hurdle step; ILL = inline lunge; ASLR = active straight leg raise; TSPU = trunk stability push-up; RS = rotary stability

Student perceptions. Students were surveyed to capture their perceptions. Sixty percent of participants either responded strongly agree or agree to the prompt, “I liked the functional movement warm-up.” Only one participant disagreed, and 36% were neutral. Written responses for what they liked about the warm-up varied. A few participants stated a specific exercise they liked while some others said it was fun or relaxing. One student stated, “It was fun to do the different stretches to see if I would improve and I did.” Another said, “It was fun in general. I also liked the 90-degree squats. I think those helped with my leg strength.” When asked what they disliked about the warm-up, the top two answers were nothing (36%) and time (28%). Most students answered nothing simply by writing “nothing” or a similar response such as “there really

is nothing I didn't like." Some responses referencing time included "how long it takes" and "3 days a week. It was long at the beginning."

Students were also asked to describe how the FMWU warm-up affected their movement. Twelve students mentioned the warm-up helping their flexibility with responses such as, "it helped me be more flexible and more functional through PE" and "The warm-up improved my flexibility and strength. I saw a difference from when we first started testing to now." One student described how the warm-up impacted her experience in marching band. She said, ". . . from the second I began this study I noticed enormous improvement. I loved this study so much and it really helped my lateral slides and marching ability." Only three students did not note any perceived changes.

Teacher perceptions. Teacher perceptions were gathered by interview. The teacher described changes in the students' ability to do the warm-up exercises. Improved balance when doing the single-leg RDLs with knee raise was the "biggest difference." She also noted improved stability during bird dogs and that some students commented when they recognized a side of the body had become easier for them. She said, "I had less than 10 but more than five that noticed themselves and said things like, 'Oh my God, I can finally do it on the left side.'" The teacher liked that the warm-up was different than what they had been doing, and it opened her mind to how exercises could be made more dynamic. She said, ". . . what I have learned from this is that you can make them (stretches) more dynamic . . . I think we get stuck in routine and don't look elsewhere for ideas even though we maybe see a need." She did not really dislike anything, but she would like to have more cardio before getting further into the exercises. She said having more cardio, "makes me feel more comfortable." No challenges were mentioned besides time in the beginning because it took a while for students to learn the exercises. Though it took more time in the beginning, she noted "that once we got it down it took less time than what we had spent on

warm-ups before." The teacher expressed additional benefits as well. She said she found herself picking out dysfunctional movements in other classes due to what she learned from participating in the study. She described recognizing misalignment of knees (i.e., knee valgus) when junior high classes were completing line hops and how she addressed it with instruction. She also discussed how participating in the study affected her thoughts about warm-ups. She stated, "[before] I approached warmups as just a way to get to the activity that we are doing for the day. To me, it was more eye-opening how lacking I am from educating from start to finish." She noted how she needs to be and can be more intentional with warm-ups.

Discussion

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 found in this research is even lower than the 14.05 (±2.48) Lester et al. (2017) reported 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 attributed to poor performance of 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, Sannasi, & Nair, 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) is the same found by Mitchell et al. (2015) in those 8-11 years old, but

contradicts Abraham et al.'s (2015) finding of the DS being the second-highest FMS task in those 10-17 years old. In this study, the criteria least likely met during the DS was keeping the dowel aligned over the feet.

Given that the DS is a functional, holistic movement pattern, it is difficult to attribute the lack of dowel alignment to any one issue. Interestingly, the total composite score and scores of 1 found in this study were worse than in previous research; however, the number of asymmetries was slightly better. The rate of participants with at least one asymmetry in this study (45.5%) is lower than Mitchell et al. (2015) found (63.8%) and Coker (2018) found (51%), although caution is warranted when comparing 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. Wright and Chesterton (2019) recently found FMS tests that require a higher rate of strength and stability typically are performed better later in maturation, and Lester et al. (2017) theorized 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. When completing 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 could 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 that tested a

different functional warm-up that included the use of exercise bands with seventh- and eighth-grade physical education students over the course of 6 weeks. In the current study, the FMWU group demonstrated slight or significant improvement in all measures of movement included 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 the HS and total composite score did not change. Even though the RWU group performed a dynamic warm-up on most days that the FMWU group completed the functional movement warm-up, the intentionality of exercise selection may explain the differences in improvement. The FMWU was designed specifically to improve movement. Exercises for the FMWU were selected with consideration of previous research and expert opinion for high impact movements. At the conclusion of the study, the teacher facilitating the warm-up expressed that before participating in the study the daily warm-up was approached as "a way to get to the activity we were doing for the day." 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.

The FMWU not only improved movement quality, but also was viewed positively by student participants and the teacher. The majority of student participants responded they liked the warm-up and when asked what they disliked, 36% said "nothing" and 28% said "time". Since most students did not expand on their answer about time, it is unclear exactly what they meant. However, the interview with the teacher sheds light on why some students may have mentioned time. The teacher stated that one challenge, in the beginning, was the amount of time it took for the students to learn the warm-up. Due to the class only being 45 minutes in length and when providing time for students to dress for class and at the end of class, they end up with only around 35 minutes of active time. With this constraint, much of the class during the first week of the

warm-up was spent learning how to perform the exercises properly. The warm-up was just under nine minutes once they had learned and practiced it the first week. The teacher noted after they were able to get the warm-up down, the FMWU group was actually done with warming up before the RWU group, and some students had asked if they could continue doing the FMWU after the research study was over. Though the FMWU initially took time away from other activities while students were learning the skills, the warm-up became a time-efficient method to improve movement quality.

There are limitations to acknowledge. Even though the 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 included in the FMWU contributed to the improvement. For the FMWU group, at least nominal improvements were found for all tests, including asymmetries and scores of 1, except the ILL, which remained constant. Without testing each exercise separately, it is unknown which exercises and/or combination created positive effects. Future research with larger sample sizes and consideration of how to discern the effect of individual exercises 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 help improve movement quality. The FMWU was not only a time-effective (less than 10 minutes) way to address dysfunctional movement in physical education, but also cost-effective. To the author's knowledge, this is the first research demonstrating an effective functional movement warm-up 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.

CHAPTER II

DISSEMINATION

Initially, the results of this project will be disseminated to local physical education teachers. A presentation will be given either during a district in-service day or the teachers will be invited to attend the session at the university where I am a faculty member. The purpose of the presentation is to share information about functional movement, the results of this research, and to teach the physical educators the FMWU. The session will include a PowerPoint (see Appendix E) presentation and an active learning segment of the warm-up. As the teachers are led through the warm-up, I will explain why the exercises were chosen and will provide instructional tips. They will also be given the Functional Movement Warm-up with Descriptions document found in Appendix D. Getting this information to teachers in the field, is an important step to impacting professional practice.

Presentation Script

Slide 1: Title Slide

Hi, thank you for being here. My name is Lynda Butler-Storsved. I am a senior lecturer at Elon University and am the program coordinator for physical education and health. Four years ago, I began the EdD in Kinesiology program at UNCG. For my dissertation, I chose to investigate the movement quality of adolescents and to test an intervention that is both inexpensive and time efficient.

Slide 2: Dysfunction Pictures

Let’s start with these pictures of the lunge, plank, and squat. What do you notice? What verbal cues would you use to help correct the movement or position? Let’s imagine we used those

cues, more explanation, and demonstration, but the student still could not perform the task properly. And, it is not that he is not understanding or not trying, but his body is not physically allowing him to perform the task properly. When physical limitations do not allow an individual to move properly through a movement pattern, we call that dysfunctional movement. Our goal is for students to have the opposite—functional movement.

Slide 3: Movement Quality

Functional movement allows the body to move with proper mechanics when performing basic movement patterns. In other words, functional movement is moving properly when we are doing activities found in real-world situations. This could be in everyday movements such as picking things up from the floor and stepping (e.g., walking, going up stairs). This also could be during physical exercise/sport such as squatting, running, and changing direction. In order to functionally move, one needs appropriate stability and mobility. Stability is being able to maintain steadiness while controlling excessive motion. Stability is necessary for balance, core steadiness, and maintaining joint integrity during movement. Good mobility is unrestricted joint movement. Mobility is not the same as merely having good flexibility. Flexibility is extensibility of soft tissues such as the stretch of a muscle or tendon that extends over a joint. Mobility not only needs tissues with extensibility to move through a range of motion, but also activation of the appropriate muscles by the nervous system, muscular strength, and proper muscular coordination, meaning contraction of the correct muscles at the required intensity to create smooth movement. Dysfunction is when there is a lack of stability and/or mobility that causes the body to compensate when completing movement patterns.

Slide 4: The Problem

The compensating movement puts stress on the bones, joints, and soft tissues (e.g., muscles, tendons, and ligaments) and musculoskeletal pain and injury can occur. According to the

kinetic chain theory, because the body is connected through a series of bones and joints, undue force (or stress) placed in one area of the body can affect another area in the body. In other words, when we have restrictions in mobility and/or stability, the dysfunctional movement can lead to trauma (i.e., pain, inflammation, and injury) along the chain. For example, limited ankle dorsiflexion can affect movement at the knee, increasing the risk of knee injuries; weak posterior hip activation or strength can increase the risk of ankle sprains; and poor thoracic spine mobility can contribute to shoulder injuries. Adolescents are already experiencing a concerning amount of musculoskeletal issues. In one study, 47% reported a physical activity-related injury in the past 12 months. In my current study, 43% said they had experienced a significant injury, one that kept them out of physical activity for 4 weeks. The pain and injury they experience contribute to school absences, a decrease of physical activity levels, and a lower health-related quality of life Also, adolescents with musculoskeletal pain are more likely to become one of the 160 million adult Americans who suffer from pain, which in turn costs the United States over $500 billion each year.

Slide 5: Why Us?

Why should physical educators take up the issue of dysfunctional movement? According to SHAPE America, the goal of physical education is “to develop physically literate individuals who have the knowledge, skills, and confidence to enjoy a lifetime of healthful physical activity” (p. 1). In order to enjoy a lifetime of healthful moving, individuals need to be able to move well. We are on the front lines, in a position to make a difference. This is what led me to my recent investigation. I wanted to know more about the extent of dysfunctional movement among adolescents, particularly ninth-grade physical education students, and wanted to determine if a warm-up intervention could help.

Slide 6: Identifying Movement

I first had to decide how I would measure movement quality. There are movement screens that have been developed to assess a person's movement quality prior to the dysfunction causing significant issues. The Functional Movement Screen (FMS) is a widely used screen with athletic populations, as well as some active job populations such as firefighters and military personnel. There are seven main tasks. Each task is scored 0 to 3. Three is the optimal score which signifies the individual could complete the movement without any compensations. A 2 is given when the movement is not perfect, but still acceptable. A 2 is considered a satisfactory score. A 1 is given if there is severe dysfunction present, where the individual cannot complete the movement pattern. A 1 indicates intervention is needed to improve movement. Lastly, a 0 is given if the individual experienced pain during the task. All the seven tasks scores are added up for a total composite score out of 21. In previous literature, the general adolescent mean scores are often near or less than 14, which has been a suggested threshold for injury. Additionally, 60% or greater have presented with at least one asymmetry. Some of the tests are scored both on the right and left side of the body and then the lower score is given for the task score. When there is a difference between the two sides, that is an asymmetry. Asymmetries have been associated with a greater risk of injury as well.

Slide 7: Current Study

FMS testing at baseline of all participants demonstrated a high rate of dysfunction among this group of ninth-graders. There was a total of 44 participants (19 male, 25 female) with a mean age of 14.25 (SD = 0.49). The FMS total composite score of all participants was 12.20 (SD = 1.56). Scores ranged from as low as 9 to as only as high as 15. Recall that a score ≤ 14 is a suggested threshold of potential injury. Ninety-five percent scored ≤ 14, 56.8% scored ≤ 12, and 22.8% scored ≤ 10. You will see almost all individual tasks mean scores are below 2. Since a

score of 2 is considered a satisfactory score, we would like to see the averages at least at 2. The SM and ASLR were the highest of the seven FMS tasks, with 79.6% scoring a 2 or 3 for SM and 81.8% of participants scoring a 2 or 3 for ASLR. The DS and TSPU were the lowest of FMS scores, with 65.9% scoring a 1 on the deep squat and 77.3% of participants scoring a 1 on the TSPU. Additionally, 45.5% of participants had at least one asymmetry. The 45% is slightly less than that found in previous research of the adolescent population, but this does not necessarily mean it is good. I don't think we should be happy with nearly 50% of the population presenting with an asymmetry. Then, possibly most concerning is that 93.2% scored a 1 on at least one FMS task. Again, a 1 signifies that intervention is needed. And, 77.3% scored a 1 on two or more FMS tasks, and 27.3% scored a 1 on four or five tasks.

Slide 8: What Can We Do?

There have been several research studies of interventions in the active adult population that have shown to increase the total composite score and decrease asymmetries. Less has been completed with the general adolescent population. Until recently, much of the focus has been on athletic populations. Of the limited research with the general adolescent population, results have been mixed. When I sought to determine an intervention, my two biggest concerns were time and money. I wanted the intervention to be realistic. I did not want it to impede the limited instructional time physical educators have with students or for the intervention to cost anything.

Slide 9: Functional Movement Warm-up

The warm-up was designed to address common issues that are seen in clinical practice when individuals score less than a 3 on FMS tasks. I took several things into consideration when creating the warm-up. I looked at previous research of interventions and research findings of exercises that demonstrated effective activation of the target musculature and exercises to improve joint range of motion. I also interviewed professionals in the fields of physical therapy

and strength and conditioning. The first seven exercises are from the Prevent Injury and Enhance Performance (PEP) Program. The program has been shown to be effective at decreasing ACL injuries. However, the entire PEP program is 15 to 20 minutes, so I did not use the entire program. I selected some exercises that emphasize form for stabilizing the knee during activity and to aerobically prepare the body for activity.

Slide 10: Functional Movement Warm-up Continued

The rest of the exercises were chosen based on their ability to affect leg, shoulder, and trunk stability and mobility. Specific issues addressed include ankle dorsiflexion, hip mobility, glute activation, thoracic spine mobility, core stability, and stability of the scapula. After reviewing the results of my research, you will have the opportunity to participate and learn the warm-up.

Slide 11: Results

The FMWU group completed the warm-up three times a week for 9 weeks. One week the warm-up was only completed once due to fall break. The warm-up took them just under 9 minutes to complete once they had learned it and had it down. The RWU group jogged and completed their typical dynamic warm-up when the intervention group was completing the FMWU. Under the posttest columns, anything colored in blue improved from pre to post. Anything colored in red worsened. As you can see, the FMWU group improved in almost every category except the in-line, which remained the same. The asterisk represents measures that significantly improved or worsened. The FMWU significantly improved in four measures, where the RWU group did not significantly improve in any measure. Actually, they significantly declined in the ASLR, trended negatively for three other measures, and their total composite score stayed exactly the same.

Slide 12: Student Perceptions

Students were surveyed to capture their perceptions. Sixty percent of participants either responded strongly agree or agree to the prompt, “I liked the functional movement warm-up.” Thirty-six percent were neutral, and only one participant disagreed. What they said they liked about it varied. A few mentioned a specific exercise they liked, while some others said it was fun or relaxing. One student stated, “It was fun to do the different stretches to see if I would improve and I did.” Another said, “It was fun in general. I also liked the 90-degree squats. I think those helped with my leg strength.” When asked what they disliked about the warm-up, the top two answers were nothing (36%) and time (28%). Time was only an issue in the beginning, because it took a while for them to learn the exercises. Once they knew them, the warm-up lasted just under 9 minutes.

Slide 13: Teacher Perceptions

The teacher was interviewed at the end of the study. She said she noticed a difference in the students’ ability to perform the exercises. She described improvement of balance and stability and she said several students verbally stated when they recognized they improved. She said learning and leading the warm-up opened her mind to other exercises for a warm-up and how to make some movements dynamic. She said she would continue to use the warm-up even though the study was over. She also noted that she found herself identifying dysfunction in other classes and she said the experience was “eye-opening.” She said that before the study she approached the warm-up as just a way to be ready for the activity for the day, and now she sees it can be used for more. Also, she said she recognized how she needs to be more present, paying attention to their movement and instructing during the warm-up, and more intentional in design.

Slide 14: Implications and Future Directions

The implications of this project include that there is a high rate of dysfunctional movement and we, physical educators, are well positioned to intervene. Also, we can do that at no cost. To my knowledge, this is the only warm-up that has demonstrated improvement of physical education students' movement quality that does not utilize any equipment. If we want students to become healthy movers now and in adulthood, we need to start being intentional about improving movement at the foundation. Moving forward, I would like to further study the FMWU in other school settings, as well as other designed warm-ups. I plan to continue to collect data concerning the scope of dysfunctional movement among the adolescent population. These data will help inform the creation of other interventions. Please let me know if you would be interested in me coming to your classes to complete this type of research. The ultimate goal is to create a packet of materials for physical educators. The packet of materials will include educational information about functional movement, the state of adolescent movement quality, methods for teaching students about functional movement and the importance of improving/maintaining movement quality, and practical interventions that can be used in physical education to improve students' movement quality.

Slide 15: Warm-up

It is now time to learn the warm-up. We will go through each exercise and I will instruct you on how to perform the exercises, explain the purpose of each, and provide you some tips when teaching them to students. All of you will be given a copy of the warm-up that includes the instructions as well (Appendix D).

Slide 16: Thank You

I would like to thank all of you for being here today and allowing me to share my work with you. If you have any questions or would like for your class to be a part of future research,

please do not hesitate to contact me. I believe creating educated, quality movers is essential for developing lifelong physically-literate individuals and this is a step in getting started. Thank you!

CHAPTER III

ACTION PLAN

The results of this project support the assertion that there is a high rate of dysfunction among ninth-grade physical education students, and that there is a need for interventions to improve movement. Physical education is a beneficial setting given the significant number of adolescents that participate in physical education each year, and the goal of physical education is to develop lifelong, physically active individuals. Intentional warm-ups, like the FMWU used in this study, is a practical way to intervene. This project is the launch point for the dissemination and further inquiry and development of interventions to address the functional movement quality of adolescents in physical education.

Short-term Plans

The initial dissemination will begin with local physical education teachers as described in Chapter II. The goals of learning session include sharing information about what functional movement is, why the high rate of dysfunction matters, and what physical education teachers can do to address movement quality. The teachers will have the opportunity to learn the FMWU and how to implement the warm-up with their students.

In my role as an educator of future physical education teachers and sports coaches, I will also include functional movement information in relevant courses. Pre-service teacher candidates will receive this information in their Senior methods course and future sports coaches in a sports injury course. The information will address movement quality, the state of dysfunction and the benefits of intervening, how to identify dysfunctional patterns, and how to implement

interventions. They will learn the FMWU and other exercises that could be used. Empowering future practitioners with this information is an important step in changing applied practice.

Long-term Plans

My long-term plans include sharing this project with a larger audience and continuing the work of addressing adolescent movement quality in physical education. To reach a larger audience, I will submit proposals to present at NCAAHPERD or SHAPE America. The presentation will include background information outlining the need for intervention, the results of this study, and hands-on teaching and learning of the FMWU. Additionally, I would like to publish a manuscript in a scholarly journal such as Research Quarterly for Exercise and Sport. Future presentations and publications would be based on the continued line of research this project began.

I am interested in further studying the FMWU in other school settings, as well as other designed warm-ups. I also will continue to collect data concerning the scope of dysfunctional movement among the adolescent population. This data will inform the creation of other interventions. As other interventions are evaluated, I will also study the teacher and student experience.

The ultimate goal is to create a packet of materials for physical educators. The packet of materials will include educational information about functional movement, the state of adolescent movement quality, methods for teaching students about functional movement and the importance of improving/maintaining movement quality, and practical interventions that can be used in physical education to improve students' movement quality. Links to instructional videos will be provided as well as an inventory of exercises that could be selected to include in a warm-up for a specific benefit (e.g., improve ankle dorsiflexion).

Empowering physical educators with the knowledge and skills to teach students about functional movement and to improve students' movement quality is needed. This work will continue to impact the local and broader community in the short and long-term. This dissertation is the beginning of a line of inquiry that will impact my professional practice and the professional practice of current and future physical educators. Adolescents' knowledge and movement quality will benefit from the applied practices developed and implemented that are informed by the results of the continued study of this topic. Creating educated, quality movers is essential for developing lifelong physically-literate individuals.

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APPENDIX A

GENERAL ADOLESCENT POPULATION FMS RESEARCH

General Adolescent Population FMS Research

Study	Age group	Sample size	Population	FMS Total Score	Asymmetries	Individual FMS Scores
Lester et al. (2017)	12-16 14.42 0.98	181	Ireland; general	14.05 (±2.48)	Not reported	Not reported
Duncan et al. (2013)	7-10	90	Britain; general	13.2 (±3)	Not reported	Not reported
Liao et al. (2017)	Middle school	120	China; general	14.98	Not reported	Not reported
Duncan and Stanley (2012)	10-11	58	Britain; general	Boys 13.5, girls 14.5	Not reported	Not reported
Mitchell et al. (2015)	8-11	77	Moldova; general	14.9 (±1.9)	63.8% with at least 1	Not reported
Coker (2018)	13.89 (±.39)	120	USA; general	15.48 (±1.88)	51% with at least 1	Not reported
Wright et al. (2015)	11-15	22	USA; general	Intervention group: 11.9 (±1.7) Control group: 12.2 (±2.1)	Not reported	Not reported

APPENDIX B

BACKGROUND QUESTIONNAIRE

BACKGROUND QUESTIONNAIRE

Write-in or circle the most appropriate answer where prompted.

Name: _____, _____ **Age**_____
First Last

Gender:

1) Male
2) Female
3) Other:_____(write-in)
4) Prefer not to answer

Height: _____

Weight: _____

ORGANIZED SPORT PARTICIPATION

Do you participate in an organized sport? (Organized sport means on a team, in or out of school, with regularly scheduled practices and competitions.)

1) Yes
2) No

Select the organized sport(s) you participate in. Circle yes or no.

A.	Volleyball	yes	no
B.	Cross country/Track	yes	no
C.	Football	yes	no
D.	Wrestling	yes	no
E.	Soccer	yes	no
F.	Basketball	yes	no
G.	Swimming	yes	no
H.	Softball	yes	no
I.	Baseball	yes	no
J.	Tennis	yes	no
K.	Other: _____ (write-in)		

Are you or will you be participating in an organized sport(s) any time between August and November 2019?

1) Yes
2) No

Turn over for more questions.

Previous Significant Injury History

Have you ever injured bone, muscle, tendon, ligaments, and/or cartilage in any body part that prevented you from participating in your normal physical activities for at least 4 weeks?

1) Yes
2) No

Select the body part(s) injured. Circle yes or no.

A.	Ankle	yes	no
B.	Knee	yes	no
C.	Hip	yes	no
D.	Back	yes	no
E.	Shoulder	yes	no
F.	Wrist	yes	no
G.	Head	yes	no
H.	Other:_____ (write-in)		

Following these injuries, were you able to eventually return to 100% of your normal physical activities?

1) Yes
2) No
3) Does not apply

Are you currently performing physical therapy exercises prescribed by a physical therapist?

1) Yes
2) No

Version 1, 5/22/19

_____

Student Perceptions Questionnaire

This instrument is to gather your perceptions about your movement quality and the functional movement warm-up. Circle or write-in the most appropriate response when prompted.

Name: _____, _____
First Last

A. The functional movement warm-up improved my movement.

5) Strongly Agree *4) Agree* *3) Neutral* *2) Disagree* *1) Strongly Disagree*

B. Describe how the functional movement warm-up affected your movement. Feel free to provide examples in your explanation.

C. I liked the functional movement warm-up.

5) Strongly Agree *4) Agree* *3) Neutral* *2) Disagree* *1) Strongly Disagree*

Turn over for more questions.

D. What did you like about the functional movement warm-up?

E. What did you dislike about the functional movement warm-up?

F. How has participating in the functional movement warm-up affected your knowledge of functional movement?

Teacher Perception Questions

Bi-weekly Check-ins During Intervention (semi-structured)

How is it going?

How is the overall engagement of the students?

Do you have any questions or concerns?

Post Interview (semi-structured)

Prior to the intervention, how would you describe your students' movement quality?

Describe any noticeable changes in students' movement quality over the 8 weeks of the functional movement warm-up.

What are your thoughts about the functional movement warm-up?

- What did you like about it?
- What would you change?
- How do you think students perceived it?

Discuss any challenges in facilitating the warm-up?

Would you continue to use the warm-up or other functional movement warm-ups?

How do you think students could benefit from learning specifically about functional movement?

How has participating in this study affected your knowledge of functional movement?

What value do you see in PE teachers learning about functional movement?

APPENDIX C

INTERRATER RELIABILITY

Interrater Reliability

	Kappa		Level of agreement	
FMS test	Pre	Post	Pre	Post
SM (right)	0.956	0.851	Almost perfect	Almost perfect
SM (left)	1.000	0.957	Almost perfect	Almost perfect
HS (right)	0.082	0.732	Slight	Substantial
HS (left)	*	0.484	*	Moderate
DS	0.388	0.640	Fair	Substantial
ILL (right)	0.357	0.709	Fair	Substantial
ILL (left)	0.436	0.864	Moderate	Almost perfect
ASLR (right)	0.352	0.500	Fair	Moderate
ASLR (left)	0.311	0.684	Fair	Substantial
RS (right)	0.300	0.356	Fair	Fair
RS (left)	0.330	0.327	Fair	Fair
TSPU	0.581	0.531	Moderate	Moderate

Note. FMS = Functional Movement Screen; 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
* no statistic computed due to HS (left) for one rater was a constant

APPENDIX D

FUNCTIONAL MOVEMENT WARM-UP

Functional Movement Warm-up

Exercise	Parameters	Purpose	Support
Jog	Across court and back	Form for knee stabilization and activity preparation	(Gilchrist et al., 2008; Mandelbaum et al., 2005)
Shuffle	Across court and back	Form for knee stabilization and activity preparation	(Gilchrist et al., 2008; Mandelbaum et al., 2005)
Backpedal	Across court and back	Form for knee stabilization and activity preparation	(Gilchrist et al., 2008; Mandelbaum et al., 2005)
Forward/backward hops	3 forward/3 backwards	Form for knee stabilization and activity preparation	(Gilchrist et al., 2008; Mandelbaum et al., 2005)
Lateral hops	3 right/3 left	Form for knee stabilization and activity preparation	(Gilchrist et al., 2008; Mandelbaum et al., 2005)
Forward run 3-step deceleration	Across court and back	Form for knee stabilization and activity preparation	(Gilchrist et al., 2008; Mandelbaum et al., 2005)
Walking lunges	½ Across court	Leg stability and mobility	(Ekstrom, Donatelli, & Carp, 2007; Gilchrist et al., 2008; Mandelbaum et al., 2005)
Low bear crawl	½ Across court	Trunk stability	(Pyka, Costa, Coburn, & Brown, 2017)
Bird dogs	3 second hold for 3 repetitions each set of opposite arm and leg	Leg and trunk stability	(Ekstrom et al., 2007; McGill & Karpowicz, 2009)
Bridge	Hold 3 seconds for 3 repetitions	Leg stability	(Ekstrom et al., 2007; Lehecka et al., 2017)
Thoracic spine rotation with reach	5 deep breaths each side	Trunk mobility	(Bradley & Esformes, 2014; *Functional Movement Systems*, n.d.; Land, Gordon, & Watt, 2017)
Inchworm with push-up plus	3 repetitions	Leg mobility, trunk stability, shoulder stability	(Ekstrom et al., 2007; Escamilla, Yamashiro, Paulos, & Andrews, 2009)

Exercise	Parameters	Purpose	Support
Single leg RDL with knee raise	3 repetitions each leg	Leg stability and mobility, shoulder stability	(Cools et al., 2007; *Functional Movement Systems*, n.d.; Granacher, Gollhofer, & Kriemler, 2010; McAllister et al., 2014)
Deep (low) squat with calf stretch	3 repetitions	Leg mobility	(*Functional Movement Systems*, n.d.; Youdas, McLean, Krause, & Hollman, 2009)
Overhead squat	3 repetitions	Leg mobility and stability, shoulder stability	(Clifton, Grooms, & Onate, 2015; Escamilla, 2001; Escamilla et al., 2009)

Functional Movement Warm-up with Description of Exercises

Jog

Jog across court and back. Inform students to keep hip/knee/ankle aligned without the knee caving in or the feet whipping out to the side.

Shuffle

Side slide with slightly bent knees across the court and back facing the same way on each pass. Inform students to keep hip/knee/ankle aligned on the push, not allowing the knee to cave.

Backpedal

Run backwards across the court and back. Inform the students to land on their toes without extending the knee. The knees should be slightly bent at all times.

Forward/backward hops

Hop over the sideline softly landing on the balls of the feet and bending at the knee. Then hop backwards. Inform students to not snap their knees back to straighten it; maintaining a slight bend in the knee.

Forward/backward hops maintaining knee bend and alignment

Lateral hops

Hop sideways over the sideline softly landing on the balls of the feet and bending at the knee. Remain facing the same way at all times.

Lateral hops maintaining knee bend and alignment

Forward run 3-step deceleration

Run across the court. As the student approaches the sideline, use a 3-step quick stop to decelerate. Inform students to not allow their lead leg knee at the stop to extend over their toe or allow the knee to cave inward. Upon return across the court the lead leg should be switched.

Lead leg knee behind toe line

Knee aligned with ankle

Walking Lunges

Lunge forward with the right leg, then push off with your right leg and lunge forward with your left leg. Continue the walking lunges across the court to the opposite sideline. Inform students to drop the back knee straight down, keeping the front knee over the ankle. Also, avoid allowing the front knee to cave inward. If the student cannot see their toes on the lead leg, they are doing the exercise incorrectly.

Knee aligned with ankle

Knee over ankle on descent

Low Bear Crawl

Assume the quadruped position (on hands and knees) with a straight spine (*setting the pelvis) and braced abdominal muscles (*bracing the abdomen). Slightly lift knees off the floor. While keeping hips low throughout, crawl across the floor to the opposite sideline using a reciprocal arm and leg pattern (opposites move together). As students continue across the floor, their hips may begin to rise. Remind them to keep hips low and to move slow and controlled.

Low position with straight spine

Bird dogs

Assume the quadruped position. Set pelvis and brace abdominal muscles. Simultaneously raise the right arm and left leg until straight and in line with the torso. Hold this position for 3 seconds and then return to quadruped. Repeat 3 times and then complete 3 repetitions with opposite arm and leg.

Opposite arm and leg raised from quadruped position

Bridge

Lay supine (face up) on the floor with knees flexed beyond 90 degrees and feet flat on the floor. Set the pelvis and brace the abdominal muscles, then lift the hips toward the ceiling until the hips are aligned with the knees (shoulders remain on the floor). Hold for 3 seconds and repeat the exercise 3 times. Inform students to squeeze the glutes on the lift.

Knees flexed, hips aligned with knees on lift

Thoracic Spine Rotation with Reach

Lay on the right side of the body with the left hip flexed slightly beyond 90 degrees (start position). Extend the right arm out from the shoulder and reach the left arm up to the ceiling. Lock the arms in this position and then rotate the left shoulder toward the floor, reaching the right arm to the ceiling. From this position take 5 deep breaths, expanding the abdomen, and on each out breath stretch a little further as able. Reverse the position to the other side and complete with 5 breaths.

Start position

Hold position

<u>Inchworm with Push-up Plus</u>

Stand with feet hip-width apart. Bend forward reaching fingers to floor, eliciting a stretch of the hamstrings. With the feet remaining in the same spot, walk the hands forward until in a push-up position. From the push-up position (with the arms straight and abdominals braced), push the upper back toward the ceiling, causing protraction of the shoulder blades. Hold this position for 3 seconds. Then slowly walk feet towards hands while keeping legs as straight as possible. Rise to start position, take two steps forward and repeat until 3 repetitions are completed.

Walk hands out

push-up position

push-up plus, pushing upper back toward ceiling

Single Leg RDL with Knee Raise

Stand on the right leg with the right knee slightly bent. The left leg should be bent enough to bring the foot off the ground. This is the start position. Now, bend at the hips and extend the left leg behind the body, lowering the torso towards the floor. At the same time extend arms back with palms to the ceiling until arms are in line or slightly beyond the torso. Keep bending until torso is as close to parallel to the floor as possible while maintaining hips parallel to the floor and a flat back. Return to the start position and immediately flex the hip bringing left knee up toward the torso. Then return to the start position. Take two steps forward and then perform the sequence on the other side of the body. Repeat until the 3 repetitions have been completed on both sides.

Start position

Hinge position with flat back and palms up

Flexed knee position

Deep (Low) Squat with Calf Stretch

Stand with feet shoulder-width apart. Lower bottom towards the floor by bending at the knees while attempting to keep feet flat on the floor. Hold at the lowest position possible for 3 seconds. Then bend forward and place hands on the floor. Slide hands out while extending hips to the ceiling, ending in a pose similar to downward dog. Push heels to the floor to elicit a stretch of the calf muscles. Hold for 3 seconds, then slightly bend knees and hold for 3 seconds. Then push back and drop back into the low squat. Repeat the entire sequence 3 times.

Deep squat

Calf stretch

Calf stretch with bent knees

<u>Overhead Squat</u>

Stand with feet shoulder-width apart, arms at sides with palms facing body and thumbs up. Set the pelvis and brace abdominal muscles. Squat to as close to parallel (thigh to the ground) as possible while maintain proper form (heels down, knees over ankles, not extensive forward flexion or arching of the spine). When moving down, flex both shoulders with straight arms until arms are as close to possible to being in line with the head, forming a “Y.” Hold the squat position for 3 seconds. Then return to the start position and repeat 3 times.

Squat hold position with arms in “Y”

<u>*Set pelvis and Abdominal bracing</u>

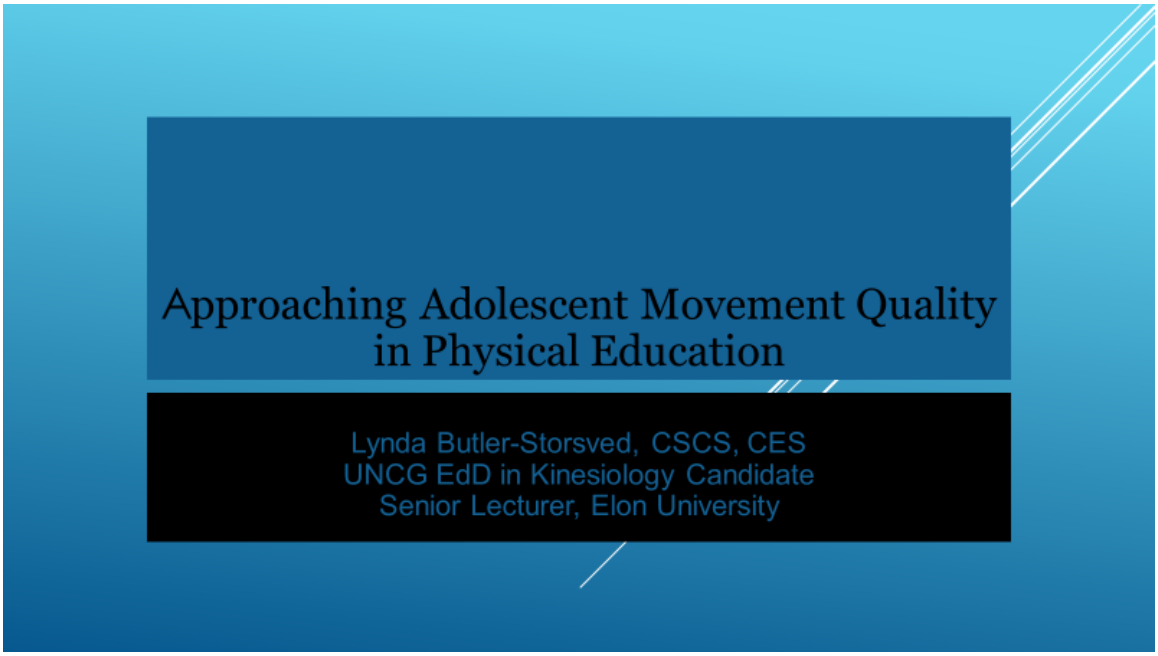
Teach this to students before beginning exercises that require setting the pelvis and bracing the abdomen.

Have students lay in a supine position with knees flexed, feet flat on the floor, and hands laying relaxed over their abdomen. Inform them they will first learn to straighten their spine by setting their pelvis. Have them take one hand and feel under their low back for the small amount of space where their back is not touching the floor. After removing the hand ask them to tilt their pelvis until the low back is touching the floor and have them hold that position. Inform them that is what will be called setting the pelvis. While they are practicing from a relaxed position to setting the pelvis, encourage them to attune to the shift of pelvis, as they will be asked to do that in different positions. Now they will add abdominal bracing. Inform the students you will be instructing them to brace their abdomen for spine support. In the same supine position, ask them to exhale forcefully as if they are blowing up a balloon until all of their air is expired, tightening their abdominal muscles as if they are about to be punched in the gut. They should hold that contraction while now breathing regularly. Inform them that is what will be called bracing their abdomen.

Set pelvis and abdominal bracing practice position

APPENDIX E

PRESENTATION FOR LOCAL PHYSICAL EDUCATION TEACHERS




MOVEMENT QUALITY


Hip
Knee
Foot
THE PROBLEM

"The goal of physical education is to develop physically literate individuals who have the knowledge, skills and confidence to enjoy a lifetime of healthful physical activity."

(SHAPE America, 2013, p. 1)

GOAL OF PHYSICAL EDUCATION

- Functional Movement Screen (FMS) Scoring
  - 0 to 3, clearing tests +/-
  - ≤ 14 potential injury threshold and asymmetries

(Kiesel et al., 2014)

- Adolescent scores
  - Often near or less than the 14 (Lester et al., 2017; Parenteau-G et al., 2014)
  - 60% or greater present with at least 1 asymmetry

(Fuller et al., 2017; Mitchell et al., 2018)

MOVEMENT IDENTIFICATION & SOLUTIONS

Descriptive	M	SD
Total composite	12.20	1.56
SM	2.39	.81
HS	1.91	.29
DS	1.34	.48
ILL	1.80	.41
ASLR	1.98	.59
RS	1.59	.50
TSPU	1.22	.42
Asymmetries	.84	.78
Scores of one	2.55	1.35

56.8% scored 12

SM – 79.6% scored a 2 or 3

ASLR – 81.8% scored a 2 or 3

DS – 65.9% scored a 1

TSPU – 77.3% scored a 1

45.5% had at least 1 asymmetry

Scores of one
- 93.2% at least 1
- 77.3% at least 2
- 27.3% at least 4

Baseline Descriptive Statistics of All Participants

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

WHAT CAN WE DO?

Exercise	Purpose
Jog	knee stabilization and activity preparation
Shuffle	knee stabilization and activity preparation
Backpedal	knee stabilization and activity preparation
Forward/backward hops	knee stabilization and activity preparation
Lateral hops	knee stabilization and activity preparation
Forward run 3-step deceleration	knee stabilization and activity preparation
Walking lunges	Leg stability and mobility

FUNCTIONAL MOVEMENT WARM-UP

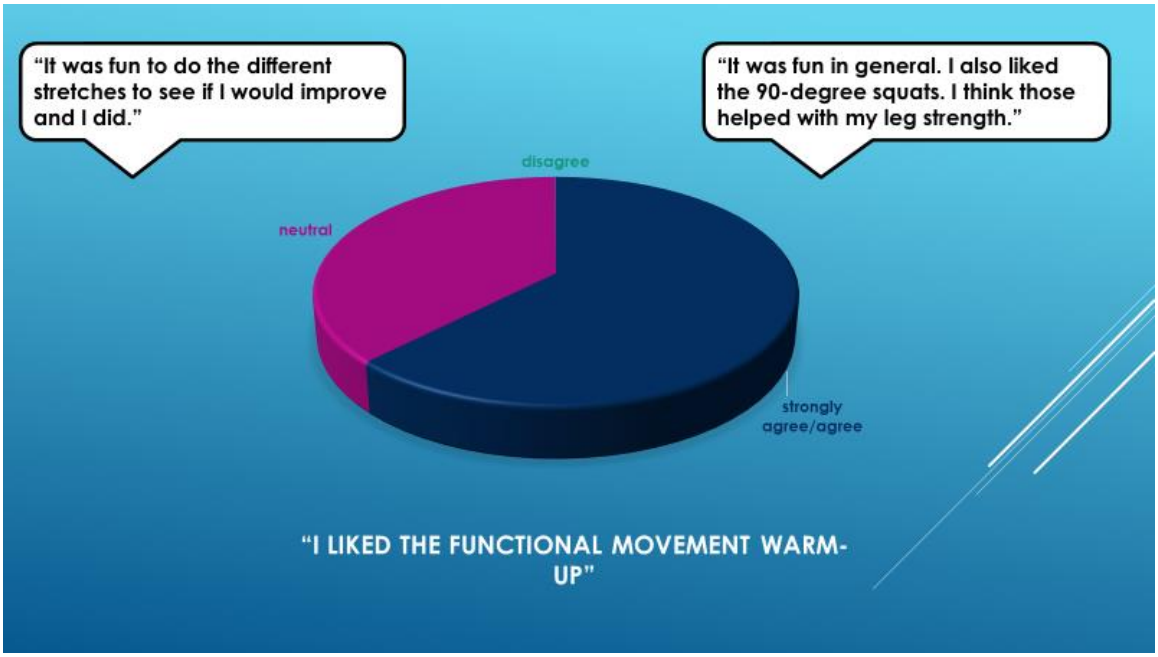
Exercise	Purpose
Low bear crawl	Trunk stability
Bird dogs	Leg and trunk stability
Bridge	Leg stability
Thoracic spine rotation with reach	Trunk mobility
Inchworm with push-up plus	Leg mobility, trunk stability, shoulder stability
Single leg RDL with knee raise	Leg stability and mobility, shoulder stability
Deep (low) squat with calf stretch	Leg mobility
Overhead squat	Leg mobility and stability, shoulder stability

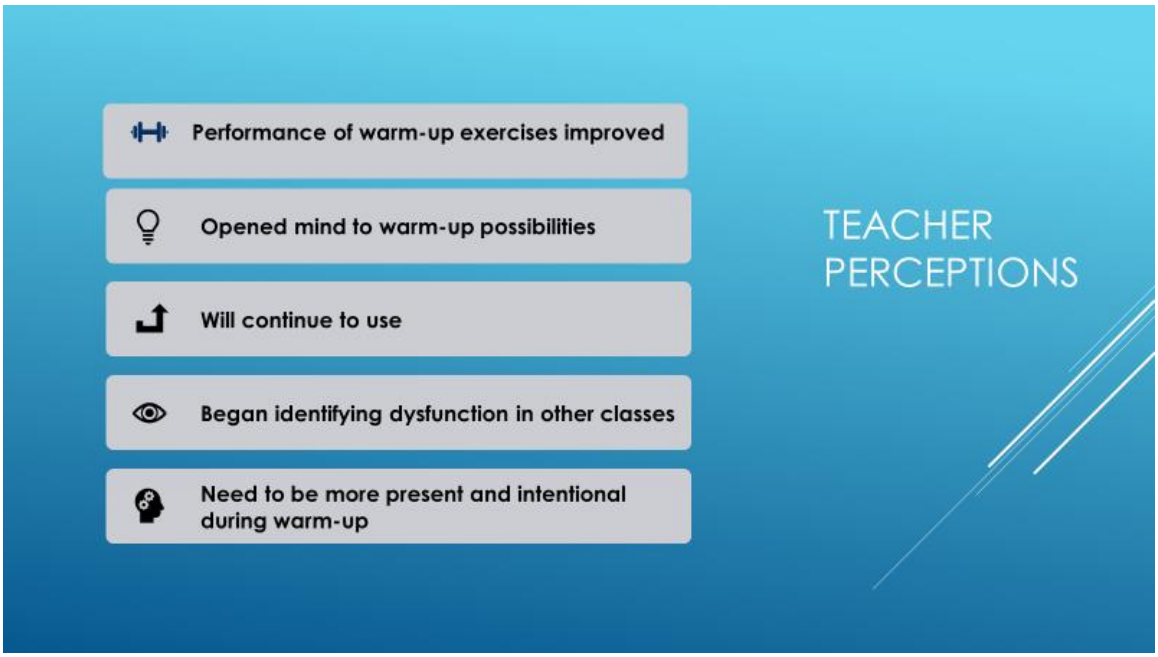
FUNCTIONAL MOVEMENT WARM-UP

RESULTS

	RWU group		FMWU group	
	Pretest	Posttest	Pretest	Posttest
Total composite	12.45	12.45	11.95	13.13*
SM	2.64	2.86	2.14	2.36
HS	1.95	1.95	1.86	1.95
DS	1.22	1.14	1.45	1.72*
ILL	1.77	1.68	1.82	1.82
ASLR	2.05	1.85*	1.91	2.05
RS	1.59	1.64	1.59	1.82*
TSPU	1.22	1.32	1.22	1.41
Asymmetries	0.77	0.55	0.91	0.64
Scores of one	2.50	2.59	2.59	1.68*

Note. Blue = improved; Red = worsened; *statistical significance
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




Performance of warm-up exercises improved
Opened mind to warm-up possibilities
Will continue to use
Began identifying dysfunction in other classes
Need to be more present and intentional during warm-up
TEACHER PERCEPTIONS


High rate of dysfunctional movement
Physical educators are well positioned
Continue to research scope and interventions
Resources for physical educators
IMPLICATIONS AND FUTURE DIRECTIONS
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TIME TO LEARN THE WARM-UP

THANK YOU!

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