Utility of the handgrip and vertical jump assessments as fitness indicators in physical education

Jessica Ann Velthoff
Iowa State University

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Utility of the handgrip and vertical jump assessments as fitness indicators in physical education

by

Jessica Velthoff

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Kinesiology

Program of Study Committee:
Gregory Welk, Major Professor
Spyridoula Vazou
Benjamin Gleason

The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University

Ames, Iowa

2018

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ABSTRACT

As research continues to provide evidence supporting musculoskeletal fitness as a strong indicator of an individual’s overall health, proposals for further evidence substantiating select indicator’s powerful link with youth health outcomes have been made. The vertical jump, a measure of lower body power, and handgrip strength, a measure of upper body musculoskeletal strength, have both been acknowledged as being strong measures of one’s health, and recommended for potential use in school fitness testing. FitnessGram®, the default fitness testing battery in United States (US) schools, is currently working to include these two measures to provide a more robust assessment of students’ musculoskeletal fitness. **Purpose:** Due to the need for further research on the utility of these measures within school physical education settings, the aim of the present study was to examine the sensitivity to change of the handgrip strength and vertical jump measures when integrating musculoskeletal and plyometric programming within school physical education settings. **Methods:** Three schools volunteered nine physical education classes to participate in the study, with classes ranging from 5th to 8th grades. Students were assessed for vertical jump and left and right handgrip strength measures prior to and following the performance of an 8-week musculoskeletal or plyometric warm-up program twice per week to examine the sensitivity to change of each measure. Classes were assigned to either a musculoskeletal strength or plyometric power warm-up program. Program assignment of participants was put in place to identify whether the training-specific goals of each program were distinguishable in results for the measure corresponding most to that goal. **Results:** At baseline, significant grade by gender differences were found for all three measures of the vertical jump, right handgrip, and left handgrip strength. An evaluation of change found no significant change.
Overall findings displayed a 4.38% improvement in the vertical jump, 1.38% in right handgrip strength, and 3.84% in left handgrip strength. **Discussion:** Findings followed suit with the principle of specificity in that the strength group displayed greatest improvement in the handgrip strength assessment, and the plyometric power group displayed greatest improvement in the vertical jump power assessment. Further studies and research will be needed to evaluate the reliability and practicality of the assessments and programs within a school PE setting.
CHAPTER 1. INTRODUCTION

Physical fitness is a vital component (and key indicator) of an individual’s overall health. It is a general state of physiological well-being that can be influenced by adhering to recommended guidelines for physical activity and/or exercise. Poor physical fitness has been linked to health problems such as obesity, and cardiovascular and metabolic diseases. Although cardiovascular disease most commonly occurs in individuals aged 50 years or older, youth with poor fitness levels have been identified as having elevated risk of metabolic precursors and co-morbidities, such as type II diabetes, high blood pressure, and elevated blood glucose levels. The link between youth fitness and disease led to the need to monitor fitness assessments in youth in an effort to prevent the early onset of these co-morbidities (Barbieri & Zaccagni, 2013; Faigenbaum & Myer, 2010).

Over the last four decades, the focus of fitness testing has transitioned from a skill-related approach that assessed performance-based items to a health-related approach that assesses dimensions of fitness more relevant to students’ overall health. Due to this shift, the battery of fitness-related items that are assessed in school physical education (PE) classes has evolved. More recently, a stronger emphasis has been placed on students’ musculoskeletal fitness, which is a construct that encompasses the combined function of three different dimensions of muscular fitness: muscular strength, muscular endurance, and muscular power (Institute of Medicine [IOM] Report, 2012).

Regular participation in muscular fitness training is recommended as part of the US Physical Activity Guidelines for Americans (Office of Disease Prevention and Health Promotion [ODPHP], 2008), and is also widely supported as a safe and effective form of training by world-renown health and fitness organizations such as the American College of
Sports Medicine (ACSM), the National Strength and Conditioning Association (NCSA), and the American Academy of Pediatrics (AAP). Improvements in an individual’s musculoskeletal fitness have been found to be inversely correlated with existing and developing cardiovascular disease (CVD) risk factors, bone density, and back pain (Faigenbaum, 2001; Faigenbaum & Myer, 2010). Longitudinal studies have also found poor handgrip strength to be a predictive indicator of heightened mortality from CVD, as well as cancer in adult men. (Massy-Westropp, Gill, Taylor, Bohannon, & Hill, 2011). In addition, a consensus report by the IOM (2012) recommended various indicators of musculoskeletal fitness be included in school fitness assessments and public health surveillance instruments. The report also proposed a need for evidence substantiating a strong link between youth health outcomes and specific musculoskeletal fitness tests - highlighting handgrip strength in particular, as current evidence supports relationships between handgrip scores and health in adults.

FitnessGram®, a youth and adolescent physical fitness testing battery, is the default national fitness testing battery in the US, and uses an established battery of health-related fitness items to assess an individual’s aerobic capacity (PACER, one-mile run, and walk test), body composition (body mass index [BMI] and body fat), flexibility (sit and reach, shoulder stretch, and trunk lift), and muscular strength and endurance (push-up, curl-up, flexed arm hang, and modified pull-up). While this battery of assessments has served the program well, additional items are currently being developed to provide a more robust assessment of musculoskeletal fitness. In line with recent recommendations (Corbin, Janz, & Baptista, 2017; IOM, 2012), new items being added include indicators that assess upper body strength (handgrip strength), and lower body power (vertical jump). Established protocols are
available for both assessments, but before the items can be built into the battery, it is important to first test how they work in practice. In order to have utility within PE settings, assessments must be sensitive to changes in youth and adolescent measures, as well as possess accurate, low-cost measurement devices that are accessible within school PE budgets. The purpose of the present study was to evaluate these measurement features and contribute to the refinement of the existing protocols for broader use in physical education programming.

**References**


Committee on Fitness Measures and Health Outcomes in Youth; Food and Nutrition Board; Institute of Medicine; Pate, Oria, Pillsbury, editors. Fitness Measures and Health Outcomes in Youth. Washington (DC): National Academies Press (US); 2012 Dec 10. 6, Health-Related Fitness Measures for Youth: Musculoskeletal Fitness. *NCBI*. Available from: https://www.ncbi.nlm.nih.gov/books/NBK241310/


CHAPTER 2. REVIEW OF LITERATURE

Handgrip Strength Research

Handgrip strength has been established as a reliable measure of upper body musculoskeletal strength when calibrated equipment and standardized protocols are utilized. Field studies have even demonstrated that reliable handgrip strength assessments can be attained when assessed by different testers (i.e., inter-rater reliability) and when using different handgrip dynamometer brands (Espana-Romero et al., 2010a).

In a systematic review by Artero, Ruiz, Jimenez-Pavon, and Espana-Romero (2010), 32 studies investigating the reliability of field-based fitness tests assessing youth and adolescents’ cardiorespiratory fitness, musculoskeletal fitness, motor fitness, and body composition were examined. The specific test items reviewed were based on the European battery used in the ALPHA (Assessing the Levels of Physical Activity and Fitness) project, a collaborative initiative that aims to provide evidence-based measures for assessing youth and adolescent health-related fitness in a standardized way across the European Union (EU). Similar to FitnessGram® within the US, the ALPHA youth and adolescent fitness testing battery is currently the standard European fitness testing method in the EU. Among musculoskeletal fitness measures investigated within the review, handgrip strength was reported as having strong evidence for being a reliable musculoskeletal fitness measure for youth and adolescent populations. In addition, four studies within the systematic review analyzing the reliability of handgrip strength in youth aged 6 to 18 years were reviewed. Results from all studies found reliability coefficients between .96 and .98. Three of these studies utilized a Takei (TKK) handgrip dynamometer and measurement protocol requiring
subjects’ elbows positioned in full extension - which is in line with the ALPHA youth and adolescent fitness testing battery used within the EU.

A study by Espana-Romero et al. (2010a) conducted under the ALPHA study framework, evaluated the reliability, feasibility, and safety of various health-related fitness tests administered within school PE settings. Students from three primary schools and three secondary schools were assessed a total of two times, one week apart, by their corresponding PE teachers for anthropometric measures and three fitness measures: 20-meter shuttle run, handgrip strength, and standing long jump. Researchers trained on the fitness testing protocol were present during testing periods to assess the feasibility of PE teachers to administer the fitness tests and to do so in a safe manner. The handgrip strength results found acceptable levels of reliability (inter-rater and test-retest), acceptable implementation feasibility, and capacity to implement safely. Overall findings of the study indicated that all health-related fitness tests performed within the study that were administered by PE teachers were safe, reliable, and feasible for use in school settings.

A second study by Espana-Romero et al. (2010b) examined the effect of elbow position on handgrip strength measures in adolescents using three criterion-referenced handgrip dynamometers: a Jamar, DynEx, and TKK. In addition, the validity and reliability of each dynamometer were compared and evaluated. The TKK dynamometer was found to possess the highest degree of validity and reliability and performed optimally when performed with the recommended protocol (i.e., individual’s elbow fully extended). These findings supported the use of the TKK dynamometer within European ALPHA youth and adolescent fitness testing battery. This evidence also supports the use of the TKK as the criterion indicator in the present and future studies. The FitnessGram® program has already
committed to including the handgrip assessment within the revised musculoskeletal battery but additional research is needed to test ways in which the measure can be best incorporated into school PE programs across the United States.

Two additional studies provide useful insights into the design of the project since they evaluated changes in handgrip following physical activity programming. A study by Melekoglu (2015) investigated the effects of physical activity on muscular fitness measures in students and, more specifically, the effects of participation in physical activity outside of PE on strength measures in 7th and 8th grade students (n = 56). One half of participating students only engaged in physical activities during their school PE classes (No Supplemental Program [NSP]; n = 28), whereas the other half of students participated in school PE classes, as well as additional physical activities (i.e., sports, athletic trainings, swimming, etc.) outside of school (Supplemental Program [SP]; n = 28). Researchers assessed students on measures of handgrip strength and vertical jump power and found that students in the SP group had greater handgrip strength and vertical jump power measures than that of the NSP group.

A study by Czarniecka, Milde, & Tomaszewski (2012) evaluated the changes in measures of strength in adolescent girls (n = 141; aged 13 ± .35 years) that participated in a 3-year PE curriculum (PEC). The PEC initially began with implementation of short exercise sessions within PE lessons led by teachers who were also trained project development team members. By the final stage of the curriculum, participants had progressed to personally creating and performing entire lessons under the supervision of a teacher. The evaluation utilized the EUROFIT testing battery, and assessed participants’ strength scores prior to, and following, the 3-year PEC for handgrip strength, bent arm hang, standing broad jump, and
sit-up tests. Significant improvements (p < .001) were found for all assessed fitness measures following the PEC. The results showed that participating girls’ handgrip strengths increased by approximately 5% and their handgrip scores were significantly stronger (p < .001) than population reference values.

The results of past research reviewed throughout this section provide justification for further research on the handgrip strength assessment and its concurrent protocols and measurement tools most effective and feasible within a school PE setting. The present study addressed this need by providing a field evaluation of the changes in handgrip strength that occurred with normal PE programming. Additional measures were taken on a small sample of students using the TKK criterion-referenced monitor which were to correspond with the students’ measures taken on the Camry field monitor- a lower cost alternative more likely to be used within school PE programs. Although not included in the analysis portion of this study, it would be beneficial for future studies to include measurement using the TKK dynamometer as well to examine the validity of the Camry field-based dynamometer.

**Vertical Jump Research**

Vertical Jump is a common indicator of lower body muscular power. Muscular power is a component of musculoskeletal fitness that reflects the rate (force and velocity), or often described as explosiveness, at which a workload is executed (Knuttgen & Kraemer, 1987). Traditional musculoskeletal fitness assessments have emphasized indicators of muscular strength and endurance, flexibility, and bone health; however, greater attention is now being placed on the role and importance of muscular power, a component previously categorized as a skill-related fitness indicator. The increased emphasis on power in fitness assessment is based on a number of studies that have documented links between power and health in the
last decade (Ashe, Liu-Ambrose, Cooper, Khan, & Mckay, 2008; Praagh & Dore, 2002; Reid & Fielding, 2012).

There is evidence supporting the inclusion of power assessments in youth and adolescent fitness testing batteries (Baptista, Mil-Homens, Carita, Janz, & Sardinha, 2016; Janz & Francis, 2015). This evidence led the IOM to recommend assessments of power in youth fitness surveillance and school fitness assessment batteries. Based on these recommendations, FitnessGram® has decided to include indicators of power in the revised battery.

One of the major health benefits of participation in muscular power related activities, other than general improvements in fitness is its bone-strengthening outcomes and optimization of one’s skeletal development. Performing movements that facilitate muscular power development in overload- or the mechanical loading of muscle forces above one’s threshold, results in the formation and strengthening of bone, particularly during childhood and adolescence. Strong evidence exists supporting the bone strengthening benefits of explosive movements (Tan et al., 2014; Weaver et al., 2016), such as its ability to develop bone in youth (Weaver et al., 2016) and minimize bone deterioration during adulthood, thus, delaying or preventing the onset of osteoporosis (Borer, 2005). These points are also the reason for inclusion of musculoskeletal fitness exercise within the U.S. Physical Activity Guidelines for Americans (U.S. Department of Health & Human Services [USDHHS], 2008).

While power can be objectively assessed in laboratory settings, alternatives are needed for use in field-based settings, such as PE. The long jump has been more widely utilized as a muscular power measure in other international batteries, such as the ALPHA
testing battery, but the FitnessGram® program has emphasized the vertical jump as the primary assessment. This is based on its more direct relation to bone health, safer administration, and greater reliability in field use, as performance of the long jump is more complex and reliant upon kinematic variables and technique (Chen, Ishii, Wang, & Watanabe, 2010; Fernandez-Santos, Ruiz, Cohen, Gonzalez-Montesinos, & Castro-Piñero, 2015). In addition to taking off with maximal explosiveness, quality performance of the long jump requires the ability to prolong time in the air, bring the feet up and reach forward for greater distance, and safely land with balance at the optimal distance (Seyfarth, Blickhan, & Van Leeuwen, 2000). The long jump also relies on skills that can impact consistency, such as momentum generated by arm swing, and launch angle. In essence, the vertical jump measure more directly evaluates power, while the long jump measure may be impacted by additional factors such as coordination, which is not the intention of the assessment. Due to this, the vertical jump assessment appears to be a more reliable assessment that can be assessed more consistently within a general population of youth in school PE settings.

In a review of musculoskeletal fitness studies conducted by the IOM committee, six high-quality muscular strength and power studies provided direct evidence of a link between muscular strength and power changes, and improvement in the health markers of BMI, body fat percentage, fat-free mass, and waist circumference. The vertical jump was among the musculoskeletal measures most consistently associated to these outcomes, spanning from late childhood to adulthood (Lubans, Sheaman, & Callister, 2010; Shaibi et al., 2006). These results highlight the positive relationship that may exist between an individual’s performance in the vertical jump assessment and important health indicators.
Another study by Ingle et al. (2006) administered a 12-week combined strength and plyometric training intervention to boys early in puberty (n = 54; aged 12.3 ± 0.3 years). Participants were randomly assigned into either a training group (n = 33) or a control group (n = 21). The training group performed three 60- to 75-minute sessions of resistance and plyometric training per week for 12 weeks, followed by a 12-week detraining period. The control group was asked to not begin any structured exercise training beyond their current physical activity habits for the duration of the study. Assessments for anaerobic power, athletic performance, and dynamic strength were performed by participants at baseline, and immediately following both the training and detraining periods. Results found a significant improvement (p < .05) of 4% in participants’ vertical jump measures immediately following the 12-week training period, as well as significant decreases in body fat percentage and increases in lean mass. These results provide justification for the proposed study, which is aimed at evaluating changes in vertical jump following a plyometric warm-up activity.

**Youth and Adolescent Muscular Fitness Training Research**

A major mission of physical educators is to promote physical literacy so that students are competent and knowledgeable about movement concepts, principles, and skills in order to maintain and achieve health-enhancing levels of physical activity and fitness. A responsible physical educator must strive to teach students to be responsible and respectful of themselves, their bodies, and others, as well as to value and enjoy physical activity for health purposes, self-expression, and social interaction (SHAPE America, 2016). Historically, there has been greater emphasis on aerobic exercise, so inclusion of musculoskeletal fitness is important for promoting optimal physical literacy that is well informed on all dimensions of health and fitness.
Before discussing research investigating various youth and adolescent muscular fitness training programs within and outside of school settings, it is first imperative to provide a foundation with age-appropriate guidelines, safety protocol, and programming discussed within a multitude of different journals. Common concerns of injury, misconceptions about what muscular fitness training actually is, and lack of knowledge in the training of youth and adolescents may discourage physical educators from incorporating it into their curriculums. By educating teachers on the age-appropriate training guidelines and protocol, as well as how to incorporate muscular fitness training in a creative, fun, and engaging way for students, school PE programs may pay greater acknowledgement to its importance and become further motivated to incorporate it into their curriculums.

Research has shown that children as young as 6 years old have benefited from strength training when using various combinations of sets and repetitions (Faigenbaum, Westcott, Loud, & Long, 1999; Isaacs, Pohlman, & Craig, 1994). Although there is currently no established minimum age requirement, it is advised that children display an adequate amount of emotional maturity in order to follow directions and understand the benefits and risks associated with strength training. A general recommendation states that if a child is ready to participate in organized sport, they are likely ready to perform some type of strength training program (Faigenbaum, 2000). Although a common concern that strength training could inhibit a child’s growth, observations indicate that no evidence of decreased stature due to growth plate damage was found in children performing strength training exercises (Faigenbaum et al., 1996).

Established protocol for youth and adolescent strength training programs emphasize that adult programs and guidelines are not appropriate. Children and adolescents who have
not yet hit full maturation benefit from strength training mainly through neural adaptations, and not hypertrophy as with fully matured individuals (Faigenbaum, 2001; Ozmun, Mikesky, & Surburg, 1994; Ramsay et al., 1990). The volume and intensity of an adult program can exceed the child’s abilities, and thus, put them at a serious risk for injury. Additional protocol for youth and adolescent strength training programs discuss the importance of a qualified instructor that is well-versed in youth guidelines and safety procedures, proper instruction using clear verbal cues, explanations, demonstrations, and practice, and close supervision to monitor for improper technique and ensure that the environment and equipment is safe.

Two school-based studies examined the effects of an 8-week integrative strength training program, performed twice per week during the first 15 minutes of a PE class, on children’s health- and skill-related fitness. In a study published in 2015, researchers cluster randomized two 4th grade PE classes (n = 41; age 9 years old) into either a fundamental integrative training (FIT) group (n = 20), or a control group (n = 21) that participated in regular PE (Faigenbaum et al., 2015). The intervention group participated in the FIT program at the beginning of each class, which was a circuit consisting of strength- and skill-based exercises. Researchers assessed students’ health- and skill-related fitness by testing for aerobic fitness (20-meter PACER test), abdominal strength (curl-up test), upper body strength and endurance (push-up test), lower body power (standing long jump and single-leg hop), and lower back and hamstring flexibility (sit-and-reach test) both pre- and post-intervention. Significant improvement was found in aerobic capacity, push-up, sit-and-reach, and single-leg hop results in the FIT group participants compared to the control group. Researchers stated that these findings of improved aerobic capacity and muscular fitness
display the potential beneficial outcomes that can be achieved by integrating both health- and skill-related fitness components into elementary school PE.

Another study published in 2014 examined the sex-specific effects of an integrative neuromuscular training (INT) program on 2nd grade children during PE (Faigenbaum et al., 2014). Children were randomized into one of two groups: a PE-plus-INT group (10 boys, 11 girls), or a control group (6 boys, 13 girls). Youth in the PE-plus-INT group participated in a program similar to that of the FIT program used in the previous study, but instead performed body weight exercises during the first 15 minutes of PE class. Subjects in the control group participated in traditional PE. Tests were performed both pre- and post-intervention and assessed children’s abdominal strength and endurance with the curl-up test, upper body strength and endurance with the push-up test, lower body power with the standing long jump and single-leg hop tests, lower back and hamstring flexibility with the sit-and reach test, balance with the stork stand test, speed and agility with the shuttle run, and cardiorespiratory endurance with the 0.8 km run test. Overall, results from this study found girls to have benefitted the most from the INT program. Girls within the intervention group displayed significant improvement on their curl-up, standing long jump, single-leg hop, and 0.8 km run test scores relative to girls in the control group. Unlike the girls, boys in the intervention group did not show similar adaptations after completing the program relative to boys in the control group. Researchers speculated one potential reason for this difference in sex-specific adaptations, after having both sexes participate in the same lessons, was that 7-year-old girls may be in a brief sex-specific developmental period that makes them more sensitive to the training program. Overall, they concluded that the INT program was time-efficient and cost-
effective, and incorporating this integrative neuromuscular training into a PE program can provide children with substantial improvements to their health- and skill-related fitness.

A study conducted by Murray and colleagues (2012), implemented a school-based physical activity intervention aimed at increasing student fitness (Murray, Eldridge, Silvius, Silvius, & Squires, 2012). Fitness assessments were conducted annually for three years to examine if the intervention achieved the intended effectiveness on youth fitness levels. Researchers examined individual FitnessGram® performances of 1,484 Texas 6th grade students over the course of 3 years. Comparisons were made between students’ first year baseline data, when students were solely performing regular PE, to years two and three data where students performed both regular PE, as well as a once-per-week physical activity intervention called FitnessGram® Friday, which was implemented to increase students’ muscular and aerobic fitness, and flexibility scores. Tests included during each assessment period were the push-up test, curl-up test, trunk lift, sit-and-reach, and 1-mile run, as well as the testing of students’ BMI. Results from baseline to post-intervention showed an average increase for boys’ push-up scores at 32.7%, trunk lift scores at 17.4%, and 1-mile run times at 29.5%. The average increase for girls’ push-up scores was 15.4%, trunk lift scores was 6.7%, and 1-mile run times was 38.6%. The percentage of boys meeting standards for all six FitnessGram® tests went from 3% at baseline to 22% post-intervention, and girls from 4.5% at baseline to 20% post-intervention. These results give further support to the implementation of a specialized PE curriculum that utilizes strength training to increase students’ fitness levels.

The present study addresses such a need by providing physical educators with a simple, pre-programmed muscular fitness training package guiding teachers through its
implementation and students through a short 10-minute muscular fitness warm-up that includes 3 minutes of dynamic stretching, followed by six muscular fitness exercise stations.

**Summary**

While there are established protocols for both the handgrip strength and vertical jump assessments, additional research was needed to determine whether these assessments had utility when used within school PE programming. The primary purpose of the present study was to determine whether these indicators of musculoskeletal fitness would be sensitive to change when used within a PE setting. Although the indicators have documented utility as predictors of body strength and power, it was important to determine if specific strength and power training in youth would lead to improvements in these fitness variables as assessed by these tests. The utility was examined by evaluating changes in both strength and power indicators following an 8-week training program that was comprised of common exercises typically performed within a PE setting. Data was collected in intact PE classes using local schools involved in a large participatory research network focused on school PE programming. Ancillary goals of this study were to provide descriptive information about levels of strength and power of students, as well as the relative utility of field-based instruments that can be used within school PE programs. It was hypothesized that students participating within the lower-body power program would display greater improvements in the vertical jump assessment of power than the strength group, and the strength group would display greater improvements in the handgrip assessment of strength than the power group.

**References**


National Standards for K-12 Physical Education - Spanish Copyright 2016, SHAPE America – Society of Health and Physical Educators, 1900 Association Drive, Reston, VA 20191,


CHAPTER 3. DESIGN AND METHODOLOGY

The present study examined pre and post changes in handgrip strength and vertical jump tests following the use of muscular fitness-improving exercises in normal PE classes. One elementary and two middle schools involved in the Iowa FitnessGram® Initiative (www.iowafitnessgram.org) were recruited to participate in the evaluation, which was IRB exempt. Schools identified at least two intact classes (5th – 8th grade) of the same grade to participate, with these classes being randomly assigned to either a musculoskeletal strength training program, or a plyometric power training program. Pre- and post-testing of students were performed prior to, and following the 8-week exercise programs to evaluate changes in muscular strength and power. It was hypothesized that classes assigned to the general musculoskeletal strength training program would display greater gains in the handgrip strength assessment (indicative of total body strength), while classes involved in the plyometric power training program would display greater improvement in the vertical jump assessment (indicative of power). Thus, the classes would each serve as a control for the other condition. The advantage of this controlled design is that it evaluates sensitivity to change using exercise routines comprised of dynamic stretches and exercises commonly performed within physical education settings. Some gains in handgrip strength and vertical jump may occur with any form of resistance exercise, but the gains should be specific for the type of exercise performed.

Schools and Participants

The study was conducted through the Iowa FitnessGram® Initiative, a large participatory network involving 84 schools in Central Iowa. A sample of 4 teachers from 3
schools agreed to participate in the musculoskeletal programs and assessments prior to the broader use within the overall network. Each individual PE teacher was asked to allocate at least two of their PE classes of the same grade level to participate in the 10 consecutive weeks’ duration of pre- and post-fitness assessments and assigned fitness training programs. Three teachers selected two classes to participate, and one teacher selected three. The selected classes for each teacher were randomly assigned to either the musculoskeletal strength training program, or the plyometric power training program. For the teacher with 3 intact classes, two classes were randomly assigned to one training program (plyometric power), and one to the other (musculoskeletal strength). The goal of recruitment was to obtain a balanced sample of students from both elementary and middle schools but the resulting sample included two 5th grade classes (n = 47 students), five 6th grade classes (n = 158) and two 8th grade classes (n = 44).

The musculoskeletal programs developed for the two conditions were designed to specifically target either strength or power. Previous research has found significant strength improvements in youth and adolescents who participated in a strength training program comprised of a 6 to 7 exercise circuit twice per week for 8 weeks, even when each session was performed for approximately 15 minutes (Faigenbam, 2015). A set of 6 specific exercises were developed for each program and each was designed to target the corresponding program’s fitness goals. The activities were set up to be used in a circuit training format with students rotating to different stations, and both programs were developed following standard, appropriate youth and adolescent strength training guidelines. Copies of the specific exercises have been provided in the Appendix.
Exercise Programming and Resources

The exercise routines were developed to be easy to use and inexpensive. The focus was on body weight exercises, although exercise bands were provided to facilitate the strength routine. Classes were provided with Blue Mountain and ProStretch brand resistance bands, which consisted of varying degrees of resistance that included extra-light, light, medium, heavy, and extra-heavy. Exercise task cards (see Appendix G), displaying visual representations and brief instructional cues for each exercise were also used to mark each exercise station for students during program sessions, and were placed within six slotted cones of differing colors (blue, purple, red, orange, yellow, green) to help facilitate instruction within PE classes. Exercises were modeled by the lead researcher prior to performance of the initial session of the program, as well as assistance from the PE teacher to provide students with further demonstration and feedback. Students within all classes were evenly divided and assigned by their teachers during the first program session to one of the six colors of cones as their starting station for the entirety of the fitness program; this assignment minimized the transition time and any potential disorganization that could occur for students between the session’s dynamic warm-up portion and the first exercise station.

Motivational workout music with built-in, timed cues was also used during sessions to notify students when to start, stop, and rotate to the next station. Two of the three participating schools were able to play the program music via sound and speaker systems already frequently utilized within their regular PE classes; the third school possessed no method in which they could play the program music, so a small Bluetooth speaker that could be connected to a mobile phone was provided to the school to enable the music to be utilized. Four progressive levels of music were used throughout the length of the fitness program, all
of which were designed to be used for two consecutive weeks before progressing to the next ‘level’ of music. Each level of music began with the same 3-minute dynamic warm-up portion, as well as six total 15-second transition periods located after the dynamic warm-up and between each of the six exercise stations. The progressive levels of music were critical for enhancing the rate and volume of work students were completing during each session, which aimed to continually promote adaptation and overload for students within the program.

Level 1 music was utilized during the first two weeks of the exercise program, and began with students performing each exercise station for 30 seconds. The total duration of a Level 1 session was 7.5 minutes when all elements of the session— the dynamic warm-up, six exercise stations, and transition time—were combined. As previously mentioned, Levels 2, 3, and 4 music each spanned two consecutive weeks and followed the same dynamic warm-up and transition period lengths as Level 1, but also varied in that each increasing level incrementally progressed the duration of each station by 5 seconds. Level 2 music was used during weeks 3 and 4 of the program; students performed each exercise station for 35 seconds for a total program session duration of 8 minutes. Level 3 music was used during weeks 5 and 6 of the program, with each station being performed for 40 seconds for a total session duration of 8.5 minutes. Finally, Level 4 music was assigned to weeks 7 and 8, with each station performed for 45 seconds for a total session duration of 9 minutes.

In addition to equipment needs, other materials were required for the organization, efficiency, and standardization of project components amongst individuals of all roles played within the project. For participating PE teachers, an individualized folder specific to their classes was created for them to keep for the duration of the project. Placed within each teacher’s folder were two sets of exercise task cards that represented exercises within each of
the two fitness programs. For setup efficiency, task cards were further separated and labelled into four specific groups: Plyometric Power Routine 1, Plyometric Power Routine 2, Musculoskeletal Strength Routine 1, and Musculoskeletal Strength Routine 2. Other items present within each teacher’s folder were copies of the two training program handouts (see Appendix D), a tentative project schedule specific to their school and participating classes for reference, and a teacher spreadsheet made specific for each of their participating classes (see Appendix F).

**Testing Procedures**

A primary goal of the project was to evaluate the sensitivity of change in common musculoskeletal fitness assessments (handgrip and vertical jump). Pre- and post-program measures for handgrip strength were assessed using two different handgrip dynamometers: the TKK handgrip dynamometer (criterion measure) and the Camry digital handgrip dynamometer (field measure) to enable comparisons. However, the focus of the present analyses was on the values from the Camry since the low cost (approximately $30) makes it a more likely option for school PE settings. Pre- and post-program measures for the vertical jump test were assessed using the Tandem Sport Vertical Jump Challenger (field measure) – a device constructed of a steel frame and moveable slats that have the ability to adjust and span heights between 4 feet to 12 feet, and measure an individual’s vertical jump height to the nearest inch, up to 24 inches.

Data collection was conducted using procedures commonly used in school physical education programming but members of the research team conducted the assessments to ensure that standardized procedures were used. Data were collected from students in a de-identified manner using coded IDs to enable scores to be collected from intact classes.
Students in participating classes were assessed immediately prior to and following their approximately 8-week exercise programs for handgrip strength and vertical jump measures. The completion of one full round of testing measures for each participating class generally required between 1 to 2 class periods depending on class period length and class size. If a student was absent on a primary day of their class’ fitness assessments where all measures of present students were completed, the student was given no scores for that round of testing. If a second day was necessary for the overall completion of the class’ fitness testing measures, and the student absent from the primary day of testing was now present, the student was then able to complete all testing measures.

At the beginning of the first pre-testing session for each class, students were assigned a unique ID number that was written on a sticker that they were to wear in a visible location on their shirt. After their initial assignment, teachers recorded the name of each student by their corresponding number assignment on the Teacher Spreadsheet provided to them in their individualized teacher folder. The use of assigned student ID numbers made it possible to track individual student’s measures over time (i.e. pre- and post-fitness tests), while still ensuring fitness measures collected were de-identified.

A team of two to four data assessors were present for each day of testing. On occasion, if few research assistants were available to assess during certain class sessions, PE teachers would be requested to help assist in taking measures. If this occurred, teachers were asked to either help assist the individual leading measurements with the vertical jump device by recording student scores on the corresponding score chart as they were performed, or take handgrip measures on one of the two handgrip dynamometers, as it was the simplest of the test measures to collect. Teachers were provided a tutorial of how to work the handgrip
dynamometer, as well as proper protocol and procedures to follow when administering the test. Hard copy handouts of all fitness assessment procedures and protocols (see Appendix E) were also provided for general reference within each teacher’s individualized folder prior to the beginning of the project.

For the handgrip, the basic protocol from the ALPHA fitness testing battery for children and adolescents was used; however, adjustments in grip size were not made for individual children. The same testing protocol and grip size was used for both dynamometers to ensure measures were standardized and comparable. This field-based protocol is more realistic for PE settings since there is limited time to change settings for individual students. The physical education classes at each of the participating schools only met for a frequency of 1 to 3 days per week, and for durations that spanned between 20 to 50 minutes per class period.

The protocol used required students to take four total handgrip attempts per dynamometer- two total attempts were performed by each hand. Students were required to alternate their attempts between their two hands so that no two attempts were performed consecutively with one hand. The alternation of each student’s handgrip attempts between hands provided an adequate rest and recovery period between attempts for the hand not performing, so that the performance of its second attempt was not impaired by fatigue that remained from its first. Students were required to perform handgrip measures standing up straight with their arms extended, no bend in the elbow, and directly by the student’s side. Additionally, handgrip dynamometers were not to touch any part of the individual’s body while making an attempt; the device was to be held slightly away from the body so as not to invalidate the measure.
The protocol for the vertical jump test was determined via contact with research professionals working through the University of British Columbia in Canada, who also provided assessor and participant procedure manuals that displayed step-by-step images along with their corresponding instructions as to how to perform the squat jump vertical jump movements and general testing administration protocol properly. The protocol used required students to perform two practice jumps prior to performing their official three jump attempts that were then measured. The specific jump performed during this test was the squat jump method. This jump requires students begin in a squatting position, with their arms held in the farthest back position during their typical arm swing for a couple seconds; this kept students from using any countermovement to help propel them higher. Each individual student was then measured to adjust the device to the appropriate height by standing directly underneath the slats, placing one hand on top of the other, and then reaching as high as possible directly overhead while their eyes were to be looking directly forward. Following adjustment, students then performed three consecutive attempts that were measured and recorded.

**Pilot Testing**

Pilot testing was conducted with the youth participants of the ISU Summer Sports Camp. The main purpose of the pilot study was to assess the practicality and ease of potentially included exercises and the general fitness programs as a whole, as well as to practice the required procedures and protocol of the two different handgrip dynamometers selected for use in the present study. Youth participant measures for handgrip strength collected during this pilot study can be found in Appendix B.
References


CHAPTER 4. RESULTS

Demographics

Two rural middle schools within the Iowa FitnessGram® participatory network that met inclusion criteria volunteered a total of seven PE classes to participate in the project: five 6th grade classes (n = 158) and two 8th grade classes (n = 44). One elementary school also volunteered two 5th grade PE classes to participate, but data from these classes were excluded from analyses due to inconsistencies in baseline data and challenges with program implementation. The removal of these 47 students caused the overall sample size to drop from 249 students to 202 students.

The two volunteer middle schools that participated within this study were both located within rural cities, and both were comprised of grade levels 6th through 8th (see below Table 1 – School Demographics). Additionally, both schools were relatively similar in size, with School 1 having a student population of 383 students, and School 2 with 348 for the 2017 – 2018 school year. Although School 1 was located in a small, rural community with a population of approximately 1,000 residents, a proportion of students enrolled in the school were from a much larger neighboring city that fell within its district boundaries. For the 2016 – 2017 school year, the school was comprised of approximately 90% White and 10% Non-White students, and held a free-and-reduced lunch rate of 9.1%. School 2 was located in a small, rural city of approximately 3,300 residents, although the district itself is made up of multiple small, rural neighboring cities located in close proximity of each other. The school is comprised of approximately 93% White and 7% Non-White students, and held a free-and-reduced lunch rate of 20.3% (Educate Iowa Reports, n.d.). A summary of these demographics can be viewed in Table 1.
Table 1 School demographics

<table>
<thead>
<tr>
<th>School Demographics</th>
<th>School 1</th>
<th>School 2</th>
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<td>6&lt;sup&gt;th&lt;/sup&gt; – 8&lt;sup&gt;th&lt;/sup&gt;</td>
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<td>Free &amp; Reduced Lunch</td>
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<td>20.3%</td>
</tr>
<tr>
<td>Ethnicity</td>
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<td>92.8% White 7.2% Non-White</td>
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</table>

**Baseline Evaluation of Musculoskeletal Fitness**

Separate baseline analyses were performed for both the handgrip strength and vertical jump assessments to identify the presence and degree of any pre-existing differences between the genders and grade levels of participating students using a two-way ANOVA (grade x gender). Results from this analysis are summarized in Table 2 located on the subsequent page. Additionally, descriptions and graphical representations of results for each of the three fitness measures of vertical jump, right handgrip strength, and left handgrip strength are provided following the subsequent page.
<table>
<thead>
<tr>
<th></th>
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<th><strong>MALES</strong></th>
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<td>8.0</td>
<td>22</td>
</tr>
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</table>
**Vertical Jump**

The results for the vertical jump test revealed significant differences by grade and gender at baseline $[F (3,196) = 6.01, p < .001]$. The gender x level interaction approached significance $[F = 3.08, p = .08]$ with larger differences between 6th and 8th graders in boys compared with girls. The gender main effect was not statistically significant, but the grade main effect was significant $[F = 13.88, p < .001; ES = .62]$ with older youth having higher scores ($39.55 \pm 7.85$) than younger youth ($34.83 \pm 7.27$). The values for the 8th graders were 9.1% higher in boys and 3.6% higher in girls. The results at baseline for vertical jump are summarized in Figure 1, below.

![Figure 1. Baseline differences of the vertical jump](image-url)
Right Handgrip Strength

The results for the right handgrip revealed significant differences by grade and gender at baseline \([F (3,197) = 31.70, p < .001]\). The gender x level interaction was significant \([F = 15.88, p < .0001]\) with larger differences between 6th and 8th graders in boys compared with girls. The gender and level main effects were both significant (Gender \([F = 3.67, P < .01]\), ES = .31; Grade \([F = 72.47, P < .0001]\), ES = 1.20) with boys having higher average handgrip scores \((24.60 \pm 7.50)\) than girls \((22.69 \pm 4.53)\) and older youth having higher scores \((29.55 \pm 7.53)\) than younger youth \((22.02 \pm 4.76)\). For gender, the values for boys were .1% higher in 6th graders and 12.7% higher in 8th graders. For grade level, the values for 8th graders were 20% higher in boys and 8.4% higher girls. The results at baseline for vertical jump are summarized in Figure 2, below.

![Baseline Differences: Right Handgrip](image)

Figure 2. Baseline differences of the right handgrip
**Left Handgrip Strength**

The results for the left handgrip revealed significant differences by grade and gender at baseline [F (3, 197) = 27.61, p < .001]. The gender x level interaction significant [F = 11.79, p < .001] with larger differences between 6th and 8th graders in boys compared with girls. The gender and level main effects were both significant (Gender [F = 12.22, P < .001], ES = .21; Level [F = 67.45, P < .001], ES = 1.23) with boys having higher average handgrip scores (22.86 ± 6.94) than girls (21.61 ± 4.45) and older youth having higher scores (27.69 ± 6.50) than younger youth (20.72 ± 4.69). For gender, the there was no difference in values between 6th grade boys and girls, although the values for boys were 10.5% higher than girls in 8th graders. For grade level, the values for 8th graders were 19.3% higher in boys and 9.0% higher in girls. The results at baseline for vertical jump are summarized in Figure 3, below.

![Baseline Differences: Left Handgrip](image)

Figure 3. Baseline differences of the left handgrip
Descriptive Analysis of Change in Musculoskeletal Fitness

A unique advantage of the design is that it allowed the relative gains in strength and power to be directly compared. Intact classes were randomly assigned to conditions with an under 10-minute strength or a plyometric power warm-up activity. It was hypothesized that strength gains would be larger in the group getting the strength warm-up while the gains in power would be larger in the group getting the plyometric warm-up. Because of the small number of 8th grade students, these analyses were run only with the 6th grade sample.

Data were first screened to check for outliers that may influence the results. The Median Absolute Deviation (MAD) method was used to identify potential outliers since this has been shown to have advantages as a defensible screening approach. There are no absolute guidelines to define outliers, but differences larger than 3 times the median difference were determined to be likely due to measurement error, improper technique or lack of effort. An advantage of the MAD method is that the absolute value of the differences from the median is used to identify outliers. This enables cases to be eliminated if they had excessively large gains or large declines in any of the three tests. The screening method identified 10 cases for vertical jump, 11 cases for left handgrip, and 11 cases for right handgrip that had excessively large deviations from the median change so these were eliminated from the analyses. The final sample size for these analyses were 158 students, although it is important to note that the maximum amount of student data used for each measure was 143 records.

The descriptive values for changes in each of the indicators are shown in Table 3 on the following page. The results of the two-way (Program x Gender) ANOVAs are summarized in the subsection below for each of the three assessments.
Vertical Jump

Results from the two-way ANOVA analysis of percent change for the vertical jump model revealed borderline significance [$F (3, 139) = 2.45, p = .07$], with an overall mean improvement of $4.38\%$. The main effect for program was found to be significant [$F = 5.05, p < .05$], with the plyometric power group displaying a greater percent change improvement in vertical jump score ($6.35\% \pm 12.35$) than that of the musculoskeletal strength group ($1.41\% \pm 13.66$). There was a non-significant program x gender interaction [$F = .01, p = .91$] and a non-significant gender main effect [$F = 2.30, p = .13$] indicating similar changes for both boys and girls. The difference in percent gain between the two groups was $5.38\%$ in males and was $4.87\%$ in females. Results for the mean percent change of the vertical jump are summarized in Figure 4, below.

![Mean Percent Change: Vertical Jump](image)

Figure 4. Mean percent change of the vertical jump
**Right Handgrip Strength**

Results from the two-way ANOVA analysis of percent change for the right handgrip strength model revealed no overall significance [$F (3, 134) = .83, p = .48$], with overall gains averaging 1.34%. An examination of the changes shows that boys from the strength group had larger gains (3.01%) compared to boys in the plyometric power group (1.01%). However, there were no appreciable differences in strength changes for girls in both of the groups. The program x gender interaction was non-significant [$F = 1.49, p = .23$] and there were also non-significant main effects for both program [$F = .23, p = .64$] and gender [$F = .79, p = .38$]. Results for the mean percent change of the vertical jump are summarized in Figure 5, below.

![Mean Percent Change: Right Handgrip](image)

Figure 5. Mean percent change of the right handgrip
**Left Handgrip Strength**

Results from the two-way ANOVA analysis of percent change for the left handgrip strength model revealed no overall significance \[F (3, 130) = 2.04, p = .11\] but the mean percent change in handgrip strength 3.84%. The program main effect was non-significant \[F = 2.56, p = .11\], but the magnitude of change is still noteworthy \((ES = .20)\). As expected, the musculoskeletal strength group displayed a greater percent change improvement in left handgrip strength \((5.18\% \pm 8.61)\) than that of the plyometric power group \((2.94\% \pm 7.51)\). The difference in percent gain from the strength program was 1.52% in males and 3.74% in females. The gender main effects \([F = 3.36, p = .07]\) approached significance but the program x gender interaction was not significant \([F = .19, p = .66]\).

![Mean Percent Change: Left Handgrip](image)

*Figure 6. Mean percent change of the left handgrip*
Distribution of Change in Musculoskeletal Fitness

The results obtained from the analysis discussed in the previous section were also used to identify the distribution of mean percent change for each of the three fitness measures between the two warm-up programs. The distribution of improvement and total percent of students who found improvement for each program and measure helps to provide a more practical understanding of the effectiveness of the goal-specific programs, as well as the sensitivity of change among the measures. A description and two histograms comparing the distributions of change between the two programs is provided below for each of the fitness indicators to more completely evaluate the changes that occurred.
Table 3 Evaluation of change

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</table>
**Vertical Jump**

The results for the vertical jump test revealed a pattern of improvement that favored opposing sides of the increasing incremental categories established for both the Musculoskeletal Strength and Plyometric Power groups. It can be noted, however, that less students feel within the central categories for the vertical jump, as the conversion of scores from inches to centimeters created a “gap” in categories where scores were not able to fall (0 – 3.9%) or less likely to fall. Overall, 40.4% of students within the Musculoskeletal Strength group and 57.0% of students in the Plyometric Power group saw improvement in the vertical jump. The greater frequency of gains in the Plyometric Power group for this assessment of power matches the outcome hypothesized prior to implementation of this study, and the principle of specificity. These findings help to support the sensitivity to change of this assessment.

![Vertical Jump Percent Change Distribution: Musculoskeletal Strength](image)

Figure 7. Strength percent change distribution of the vertical jump
The results for the right handgrip strength test revealed both programs followed a pattern that favored the lower categories of change. The vast majority of students displayed a change that fell below that of their pre-assessment score, followed by a pattern of slight decrease in frequency as categories increased in percent improvements. Overall, 57.1% of students within the Musculoskeletal Strength group and 52.4% of students in the Plyometric Power group saw improvement in the right handgrip strength test. The greater frequency of gains in the Musculoskeletal Strength group for this assessment of upper body strength again matches the outcome hypothesized prior to implementation of this study, and the principle of specificity. These findings help to support the sensitivity to change of this assessment.
Figure 9. Strength percent change distribution of the right handgrip

Figure 10. Plyometric power percent change distribution of the right handgrip
**Left Handgrip Strength**

The results for the left handgrip strength test revealed the Musculoskeletal Strength group favoring opposing sides of the categorical spectrum, while the Plyometric Power group followed a similar pattern to the right handgrip test that favored the lowest category of change, and slightly decreased in frequency as categories increased in percent improvements. Overall, 72.9% of students within the Musculoskeletal Strength group and 62.2% of students in the Plyometric Power group saw improvement in the left handgrip strength test. As with both previous measures discussed, the greater frequency of gains in the Musculoskeletal Strength group for this assessment of upper body strength matches the outcome hypothesized prior to implementation of this study, and the principle of specificity. These findings also help to support the sensitivity to change of this assessment.

![Left Handgrip Percent Change Distribution: Musculoskeletal Strength](image)

**Figure 11.** Strength percent change distribution of the left handgrip
Figure 12. Plyometric power percent change distribution of the left handgrip

References


CHAPTER 5. DISCUSSION

Key Findings

The present study was designed to evaluate the utility of two musculoskeletal fitness assessments (handgrip and vertical jump) for evaluating strength and power in youth and adolescents. The study used an ecologically-sound, controlled design to evaluate the sensitivity to change of these assessments with intact physical education classes. It was hypothesized that classes receiving the plyometric-based warm-up would have larger gains in power while the group receiving the circuit training warm-up would have larger gains in strength as assessed by the handgrip. The results generally supported these hypotheses. Significant program main effects were found only in the vertical jump measure, but the strength gains were also consistently larger for the classes assigned the strength training protocol. The lack of significant program effects in these cases can be attributed largely to the fact that the control group also received a comparable program of exercises. The principle of specificity certainly suggests that gains would be larger based on the type of program that was performed but youth with low levels of fitness may have gained from almost any type of program.

Results did not reveal any significant gender main effects, but the gains were consistently larger for males than for females. In all three measures, the mean change percent of males was approximately two times that of females. These findings match those of Ploegmakers et. al (2013) which discusses the strong association between grip strength and gender and age of children. In the article, the researcher highlights how for both genders, progression is linear and parallel up until age 11 or 12. Following these ages, the development of handgrip strength displays a more prominent acceleration in males; these
patterns follow suit with the findings within the present study, as males consistently achieved
greater scores, and 6th graders displayed much less difference in scores between genders than
that of 8th graders. Although this seemingly gives the notion that males achieved greater
gains than females, it is also important to take into account the considerable variability in
change scores for both boys and girls. The large variability is likely why these differences
were not statistically significant.

Finally, findings of the handgrip assessment showed greater strength gains in the left
hand than the right hand. Although unable to truly determine why this outcome occurred, one
potential explanation could be based on the handedness of the participants. Although
outcomes have varied to some extent, studies have found that right hand-dominant
individuals, which make up approximately 90% of the population, are significantly stronger
in their dominant hand than their non-dominant; the same was not found to be true among
left hand-dominant individuals (Armour, Davison, McManus, 2014; Incel et. al, 2002).
Research has also shown that increases in muscular strength are on average greater in
untrained individuals than individuals who are trained, although this is also dependent on
variables such as type of program, intensity, and frequency (Maud & Foster, 2006). Taking
this into account, one could hypothesize that greater improvements were seen in the left
handgrip measure in comparison to the right due to the higher likelihood of it being untrained
and weaker in nature to the right, and thus, more likely to achieve greater strength gains from
the training programs.

The results are noteworthy considering the relatively small dose of exercise that was
performed (10-minute warm-up routines performed twice per week for eight weeks). This
program was selected intentionally since it was important to test a fitness activity that would
be more likely to be implemented in normal PE settings. The selected program was
developed with the purpose of providing PE teachers with a practical, reliable, and age-
appropriate method in which they can incorporate musculoskeletal fitness training and
assessment effectively into their PE programs. The gains demonstrate that improvements in
strength and power can be detected even with this relatively small dose of training. It is
important to note that although the purpose of the warm-up programs was to improve the
musculoskeletal fitness of students, greater volumes of training, resistance, and/or exercise
differentiation would likely provide a stronger stimulus that would result in increased
improvements in training outcomes.

Relevance for Physical Education

The warm-up programs for this study were designed for efficiency and feasibility
within the context of school PE classes, which can vary greatly in duration and size, as well
as the fitness levels, and developmental and skill abilities of the students participating in
them. That being said, the overall goal of these short-term programs was not to achieve
maximal gains, but strong improvements in students’ musculoskeletal fitness. It was also
expected that students starting with a higher musculoskeletal fitness level or who had more
experience with such training at baseline would show less improvement than those who were
beginning at a lower level or new to the type of training. Although these programs were
created with set exercise lists and incremental progressions of the exercise and session
durations, modifications for both increasing and decreasing the difficulty of each exercise
were instructed and demonstrated to students within each participating class prior to the start
of the first program session. Providing such modifications was done to help better ensure that
the wide-ranging needs and abilities of all students were appropriately challenged – an
important component of the training programs that is not just relevant to implementation within this study, but to the potential future implementation of the programs into PE classes that will be strongly guided by the unique instruction of each teacher.

The overall framework and findings from this study can be used as a foundation for future studies after identified areas of weakness are modified and improved into a more effective set of programs, tools, and protocols that foster greater achievement in student outcomes. Additionally, findings from this study and future studies provide valuable insights about the sensitivity to change of two commonly used musculoskeletal fitness assessments.

**Strengths and Limitations**

**Strengths**

Overall, this study held many strengths. Although the environment in which the study was conducted can be seen as a limitation due to its potential effects on the validity of the collected data, it can also be seen as a strength. This study is focused on finding reliable and effective fitness measures and programs that can be easily implemented within school PE classes by teachers. In this case, establishing an environment that was completely free of any of the environmental factors and challenges typically seen within a school PE program such as varying lengths of class periods, setup time between class periods, absent students, holidays, student effort, and classroom attitudes, expectations, and behaviors, would result in findings that were not as applicable or direct in evidence of the reliability, feasibility, and effectiveness within a true PE context.

Building upon this, a more focused strength of this study was the feasibility of the utilized measurement tools within a school PE program. Because the overall goal of this research is to be able to supply relevant information that is achievable across the spectrum of
varying school PE programs, the selection of the equipment used to assess both measures of student fitness placed great importance in their affordability and ease of use. Highlighting the broad notion that PE programs can vary greatly from one another, as previously mentioned, this concept more specifically can apply to both PE budgets and class period duration and size. The equipment used within this study was cost-effective and simple to use, and not only displayed sensitivity to change, but also found differentiation between the program changes for each measure that followed suit with research revolving around the principle of specificity.

Another strength of the fitness measures was the perceived enjoyment that many of the students had in performing them. Although both assessments often looked to invoke novelty and excitement among students, the vertical jump assessment appeared to have greatest popularity among classes. Many students were eager to have a turn and make their jump attempts with the device, and would sometimes ask at the conclusion of assessments if they could have more informal jump attempts to try to beat their previously assessed scores. Overall for both assessments, students seemed eager to see what their scores were, but also to achieve higher scores than they did in their prior attempts. They also often found great entertainment in watching their teacher or some of the research helpers make attempts on the measures and hearing what their scores were; this willingness to positively interact and participate with the students and assessments is one meaningful method that can be used to encourage student enjoyment and participation within the fitness assessments and programs.

Along with the equipment, the programs utilized within this study were also designed for feasibility within PE classes. The programs were short in duration so to fit into the schedule of a range of different class period lengths, and created to be used as a warm-up
routine at the beginning of a class period – a portion of class time often already set aside for some type of dynamic warm-up activity. Program set-up and clean-up was made to be simple and time-efficient, with the only required equipment being a Bluetooth or internet-accessible device and speakers capable of playing the program music at an audible level for participating students, six slotted cones, each with an assigned exercise task card placed within them, spaced in a safe and organized manner around the gym, and two stations of resistance bands for the standard musculoskeletal strength program sessions.

One method found to be most helpful in the placement and increased movement efficiency of program equipment was the requesting of student assistance with various components of the set-up and tear-down process, particularly after completion of the initial program sessions that familiarized them more with the routine structure and equipment layout. Further benefits of students assisting in this process are that it provides them an opportunity to take a more active role of leadership and responsibility within the class. Providing this opportunity can be especially meaningful to those students that consistently display motor skills and abilities that they may feel lack in comparison to their in-class peers, and/or do not meet the national standards established for their corresponding grade-level (SHAPE America, 2013). These students may often find greater challenge in accomplishing the tasks and performing the activities requested within PE lessons, and thus, may feel discouraged and incapable of achieving such leadership roles, as many of these opportunities are presented in the context of team activities and competitions, and generally favor the students possessing the strongest set of skills, abilities, and experience. Providing such opportunities to these particular students, and all students in general, can help to not only foster a stronger sense of belonging and purpose in the classroom via personal contributions
and responsibilities, but teach students about the extensive number of roles that are crucial to the function of various sporting events and activities beyond the role of a competitor – some examples may include referees, coaches, timekeepers, team captains, scorekeepers, equipment managers, and statisticians, depending on the sport or activity.

Furthermore, the ability to swiftly and easily set-up and put away equipment showed to be especially paramount in the schools with little to no transition time between class periods. Although it seems logical that future implementation of the warm-up programs by PE teachers into their PE programs would be done so in all of their scheduled class periods throughout the day, and thus, no complete equipment set-up or tear-down would be necessary between classes, it is important to note that this is not an option in every case. A range of differences can exist both within and between the static and dynamic characteristics and circumstances of each individual school’s PE program. Some such aspects that may affect the frequency and rate at which warm-up program equipment must be moved throughout the course of a school day include class activities, grade and developmental levels, the size or layout of the gym and equipment storage room, or special events being held within or impeding upon the gym space – to name a few. These vast differences and circumstances that can exist or arise, at times unexpectedly, were strongly taken into account during the planning and construction of the warm-up programs to ensure implementation was not only feasible for PE teachers, but quick and simple so that it did not feel like an added stressor or obstacle to face before proceeding with their regular lessons.

Moving beyond the simplicity of equipment, the implementation and performance of these warm-up programs taught students about musculoskeletal fitness and its benefits, and how to properly perform a variety of different exercises to improve upon their present level
of fitness. Students were also taught how to appropriately modify exercises if needed, and about the importance of performing these exercises in a way that provided them with the most optimal level of challenge for their individual needs. In doing this, it was also crucial for students to understand that the goal was to focus and improve upon themselves, and not compare their performance and achievements to others. Providing students with all of these valuable tools has the ability to foster a stronger understanding and ability to perform musculoskeletal fitness activities, and with this feeling of competency, can promote a more positive attitude toward such activities and greater motivation to continue performance both now and in the future.

Limitations

Many limitations present within this project were the product of its use in a field-based setting, which likely increased its exposure to confounding variables during the process of implementing fitness programs and collection of data during fitness assessment periods. At a broad level, with changing school and class schedules and times, it was not always possible to administer the two fitness each week due to factors such as holidays or occasions that resulted in no school, classroom assessment days, and block schedules that only met for PE once every three days. That being said, the quantity of program sessions each class performed varied. Additionally, the week that the fitness post-assessments were to fall found to be the week of Thanksgiving Break. There was no school the Wednesday, Thursday, and Friday of this week at any of the participating schools, as well as the ISU Thanksgiving Break that left few research assistants in the area to assist with the administration of fitness tests amongst the various schools. Due to this, fitness post-
assessments were moved to the week prior so not to expose students to a week and a half of potential sedentary time with no program sessions prior to collecting fitness measures.

Along with scheduling and differences in the number of sessions performed, other factors may have impacted findings within this study. Variation in PE curriculums and activities that students were involved in outside of the fitness programs administered is one broad factor that could have impacted the results found within students’ fitness scores. Additionally, tweaks that were made to fitness programs to better accommodate teacher preferences and needs could have also changed the effectiveness of the programs performed by the corresponding students.

At a teacher and student specific level, variations in teaching style and attitudes, as well as the motivation, behaviors, and attitudes of students also may have played a role in the effectiveness of both the fitness programs and the test results. The amount of involvement of the teacher during the programs and testing, as well as their encouragement and motivation seemed to have had an impact on how much effort students gave and the attitudes they had in regard to the various components of the project. Additionally, some of the PE teachers had a discussion with students at the beginning, as well as intermittently throughout the progression of the programs to provide and remind them of the purpose of the project activities they were participating in. Providing students with meaning behind what they are doing and its importance are crucial in the motivation and adherence to the programs of students.

Further factors limiting this study were the lack of participant data including height, weight, and stage of development, as well as hand dominance of the students. Including these
pieces of information would have given further depth to the data collected and the detailed effects of the intervention and assessments on participating students.

One final limitation to this study was the time constraint. The process and many detailed elements that required execution during the planning, preparation, and implementation of this study were limited to one semester to complete, as a change in study topic occurred due to my previous advisor’s move after obtainment of a new job. The small frame of time also made it challenging to recruit and train a large enough team of research assistants to help with the continuing implementation of the project. Due to their school-related responsibilities being first priority as students, assigning sessions that were scheduled to be implemented at the three different schools each week found to be difficult, especially for a couple specific reoccurring time slots, due to time conflicts in research assistants’ class schedules.

**Practical Applications and Future Work**

The major focus of the present study was to identify new methods of musculoskeletal fitness measurement and improvements that were practical and effective within a school PE setting. This study was the first attempt at implementation of the warm-up programs and assessment tools with their respective protocols. The framework and findings from this study has been, and will continue to be, used to lay the foundation for future implementations after adjustments and improvements have been made. These adjustments will be made largely based on the factors discussed within the previous strengths and limitations section, as well as further research interests and gaps that may progress into the spotlight as time and continued implementations move forward into the future.
A second phase of this project has already completed the implementation process within a larger sample of volunteer schools; similar to this first study, recruitment of schools for the second phase also required they be members within the Iowa FitnessGram® participatory network. Although the study followed a similar structure to this initial one, adjustments were made prior to its implementation that provided the PE teachers with control of taking and recording student fitness measures and implementing the 8-week warm-up program. Teachers were provided with all of the necessary equipment and materials, as well as a teacher manual that gave detailed instructions and protocols on each portion of the project. They were also given a timeline of when to do each portion of the study, as well as a weekly reminder email from a project leader each week stating all of the tasks they were to be doing and the progressive level of music they were to be on. Although teachers were given the responsibility of fully implementing all of the project components into their selected PE classes, they were provided multiple methods in which they could communicate with project leaders for additional support if needed. Overall, this second phase was performed to provide an enhanced understanding of how feasible and effective these musculoskeletal fitness assessments and programs are in a full teacher-led PE setting.

Additionally, creating programs that better celebrate and are more inclusive to diverse cultures and populations is another key element that would greatly benefit future implementations of this project. Although the second phase of this study incorporated more culturally inclusive task cards, continued effort should be made to create more diverse and inclusive programs that celebrate and adapt to the many differences present between individuals. With this, obtaining feedback from students and teachers on their perceptions and feelings toward the programs and assessments, and using this information to work
toward a more optimally tailored and enjoyable experience for those implementing and performing them will likely lead to greater adherence and effort in performance.

Following future implementations and establishment of an optimized musculoskeletal warm-up program and its corresponding equipment, teacher materials, and protocols, the long-term goal for this program is to be able to package and provide it as a free tool and guide for teachers to use in their school PE programs. As mentioned, it will be important to solidify a practical, effective, inclusive, and engaging program package prior to reaching this goal. Beginning initial implementations with focus on the general foundation and structure, and then gradually building up to refinement and the smaller details will over time help to identify program items that may find benefit from changes or exclusion, items for inclusion that may not have been initially thought of, and items that could be expanded upon for a greater reach and relevance to participants, such as more exercise modifications or variations for students to choose from to meet their unique needs and interests, and extended or varied versions of programs and/or program music to continue progression and student improvement. Additionally, creating programs that better celebrate and are more inclusive to diverse cultures and populations is another key element that and Furthermore, this period of progress and program evolution must also place aim to identify the grade levels in which the program is both developmentally appropriate and most effective, as well as its flexibility and adaptability among a wide array of different PE environments and teachers. Upon use and observation thus far, the current PE program has looked to find greatest utility within a middle school PE setting. One direction of interest following future establishment of this “core” program is to then move forward and further seek ways in which to modify the
program to best meet the needs and level of challenge appropriate for students at the elementary and high school levels.

Similarly, future implementations of the fitness assessments utilized within this study will help to guide any further changes in equipment selections and protocols within the PE context. It will also be important, as with the programs, to identify the age-appropriateness of these assessments when performed by students in PE class. Although an assessment may seem simple in performance, it is also crucial for students to understand what they are doing and why they are doing it; fully understanding this and applying it into their performance deter the frequency of submaximal attempts by students who did not fully understand the consequence of not performing to his or her best. Furthermore, the long-term goals of these fitness measures following future implementations of assessments are to establish a standard and effective protocol for each, and a particular brand and product of equipment for each measure that is cost-effective, reliable, and feasible within a PE setting, and whose outcomes are sensitive to change. Further research on the utility and sensitivity of these measures within a school PE setting will help to support the decision for their potential future incorporation into the FitnessGram® testing battery.

References


Date: 2/18/2016
To: Dr. Gregory J Weik
    257 Foraker Bldg

From: Office for Responsible Research

Project Title: Iowa Fitnessgram Initiative

The Co-Chair of the ISU Institutional Review Board (IRB) has reviewed the project noted above and determined that the project:

☐ Does not meet the definition of research according to federal regulations.
☒ Is research that does not involve human subjects according to federal regulations.

Accordingly, this project does not need IRB approval and you may proceed at any time. We do, however, urge you to protect the rights of your participants in the same ways you would if IRB approval were required. For example, best practices include informing participants that involvement in the project is voluntary and maintaining confidentiality as appropriate.

If you modify the project, we recommend communicating with the IRB staff to ensure that the modifications do not change this determination such that IRB approval is required.
### APPENDIX B. PILOT STUDY SCORESHEET

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APPENDIX C. PROJECT FLYER

Iowa FitnessGram Initiative

Evaluation of New Muscular Fitness Tests for FitnessGram

Background
➢ The Cooper Institute is working to develop assessments and standards for a new musculoskeletal fitness profile that will include 3 new fitness tests
  ○ Plank – indicator of core strength and endurance
  ○ Vertical Jump – Indicator of lower body power
  ○ Handgrip – Indicator of total body strength
➢ The Iowa FitnessGram Initiative will be working to pilot the new assessments to ensure that they have good utility for use within FitnessGram.

Project Overview
➢ Project will involve elementary and middle schools (5th - 8th grade PE classes)
➢ Project will require participating schools to identify 2 intact classes of students to participate.
➢ Project will have 3 phases (see image below)
  ○ Classes will complete Pre-Tests evaluation of muscular fitness (administered by ISU Team)
  ○ Classes will complete structured warm-up activities in normal PE (facilitated by ISU Team)
  ○ Classes will complete Post-Test evaluation of muscular fitness (administered by ISU Team)
➢ Project will take place in the 2017/18 year, starting late September and running through mid-November
➢ Project will be conducted completely by ISU team, but some assistance with coordination will be needed

Benefits
➢ Participating schools will receive a free muscular assessment testing equipment
  ○ Camry Digital Handgrip Dynamometer
  ○ Blue Mountain Resistance Bands - Set of 5 bands of varying resistance
  ○ Vertical jump wall measurement tool.
➢ Teachers will receive reports showing their class summary outcomes of assessments
APPENDIX D. WARM-UP PROGRAMS

Musculoskeletal Fitness Warm-Up Activity

This program is designed to help incorporate musculoskeletal exercise into normal physical education programming. The routine is designed to be conducted as an approximately 10 minute activity that can be incorporated as an introductory warm-up at the beginning of class. The program is set up in the form of an exercise circuit that cues children to move quickly from station to station, and promotes overall improvement of their musculoskeletal fitness. There are 2 distinct phases which are to be performed consecutively and in the order prescribed in the handout.

I. Dynamic Warm-Up (~3 minutes total)

A dynamic warm-up is important to prepare students for the exercise circuit. Have the students move about the perimeter of the gym for approximately 3 minutes, calling out the list of dynamic movements in order after 10 repetitions (per side, if alternating). Perform the following 5 movements in a large circle around the gym (ex: outside of basketball court boundaries) as their dynamic warm-up. Have students start walking around the gym as they filter in until all students are present, to which the instructor may then begin the dynamic warm-up routine.

1. Walking hamstring stretch
2. Walking opposing hand to toe touches
3. ¼ Lateral squats (both directions)
4. Inchworms
5. Jog

II. Circuit (~6 minutes total)

The main circuit training component is designed to have students quickly and efficiently perform different strength exercises. Students will attend 6 stations using slotted cones with inserted exercise cards. Two circuit routines will be alternated between, therefore each routine will be used only once per week. Routines target all major muscle groups, and include a balance of bodyweight (BW) exercises and resistance band (RB) exercises to provide variety. A sample image is included below to show the layout of the stations and the movement flow around the gym. Students will perform each exercise for 30-45 seconds depending on which week of the program they have progressed to, with a transition time of approximately 15 seconds between stations.

- **Routine 1**
  1. Push-ups
  2. BW squat hold with RB Bicep curls
  3. RB Shoulder press
  4. Moving plank (side- side / left-right)
  5. RB Reverse flies
  6. Alternating back extensions (opp. arm- leg)

- **Routine 2**
  1. Moving plank (side- side / left-right)
  2. RB Lateral shoulder raise
  3. RB Chest flies
  4. Alternating back extensions (both arms-both legs)
  5. Burpees (with push-up, NO jump)
  6. Curl-ups
Plyometric Power Warm-Up Activity

This program is designed to help incorporate power and plyometric exercise into normal physical education programming. The routine is designed to be conducted as an approximately 10 minute activity that can be incorporated as an introductory warm-up at the beginning of class. The program is set up as a form of an exercise circuit that cues kids to move quickly from station to station, and promotes overall improvement of their aerobic fitness and plyometric power. There are 2 distinct phases which are to be performed consecutively and in the order prescribed in the handout.

III. Dynamic Warm-Up (~3 minutes total)

A dynamic warm-up is important to prepare students for the exercise circuit. Have the students move about the perimeter of the gym for approximately 3 minutes, calling out the list of dynamic movements in order after 10 repetitions (per side, if alternating). Perform the following 5 movements in a large circle around the gym (ex: outside of basketball court boundaries) as their dynamic warm-up. Have students start walking around the gym as they filter in until all students are present, to which the instructor may then begin the dynamic warm-up routine.

1. Walking hamstring stretch
2. Walking opposing hand to toe touches
3. ¼ Lateral squats (both directions)
4. Inchworms
5. Jog

IV. Circuit (~6 minutes total)

The main circuit training component is designed to have students quickly and efficiently perform different plyometric exercises. Students will attend 6 stations using slotted cones with inserted exercise cards. Two circuit routines will be alternated between, therefore each routine will be used only once per week. Routines target all major muscle groups, and include a variety of body weight (BW) plyometric exercises. A sample image is included below to show the layout of the stations and the movement flow around the gym. Students will perform each exercise for 30-45 seconds depending on which week of the program they have progressed to, with a transition time of approximately 15 seconds between stations.

- **Routine 1**
  1. Squat jumps
  2. Moving plank (side- side / left-right)
  3. Forward/Backward line jumps
  4. Side lunges
  5. Burpees (With jump, NO push-up)

- **Routine 2**
  1. BW squats
  2. Moving plank (side- side / left-right)
  3. Alternating 180° squat hops & shoot
  4. Lateral line jumps (side to side)
  5. Jumping lunges
  6. Sprints (down & back)
Alternative Musculoskeletal Fitness Warm-Up Activity (Body Weight Only)

This program is designed to help incorporate musculoskeletal exercise into normal physical education programming. The routine is designed to be conducted as an approximately 10 minute activity that can be incorporated as an introductory warm-up at the beginning of class. The program is set up in the form of an exercise circuit that cues children to move quickly from station to station, and promotes overall improvement of their musculoskeletal fitness. There are 2 distinct phases which are to be performed consecutively and in the order prescribed in the handout.

V. Dynamic Warm-Up (~3 minutes total)

A dynamic warm-up is important to prepare students for the exercise circuit. Have the students move about the perimeter of the gym for approximately 3 minutes, calling out the list of dynamic movements in order after 10 repetitions (per side, if alternating). Perform the following 5 movements in a large circle around the gym (ex: outside of basketball court boundaries) as their dynamic warm-up. Have students start walking around the gym as they filter in until all students are present, to which the instructor may then begin the dynamic warm-up routine.

1. Walking hamstring stretch
2. Walking opposing hand to toe touches
3. ¼ Lateral squats (both directions)
4. Inchworms
5. Jog

VI. Circuit (~6 minutes total)

The main circuit training component is designed to have students quickly and efficiently perform different strength exercises. Students will attend 6 stations using slotted cones with inserted exercise cards. Two circuit routines will be alternated between, therefore each routine will be used only once per week. Routines target all major muscle groups by utilizing a variety of basic bodyweight (BW) exercises. A sample image is included below to show the layout of the stations and the movement flow around the gym. Students will perform each exercise for 30-45 seconds depending on which week of the program they have progressed to, with a transition time of approximately 15 seconds between stations.

• Routine 1
  1. Push-ups
  2. Reverse plank
  3. Lunges
  4. Moving plank (side- side / left-right)
  5. Reverse inchworms
  6. Alternating back extensions (opp. arm- leg)

• Routine 2
  1. Moving plank (side- side / left-right)
  2. Reverse push-ups
  3. Plank with alternating shoulder touches
  4. Alternating back extensions (both arms-both legs)
  5. Burpees (with push-up, NO jump)
  6. Curl-ups
APPENDIX E. FITNESS ASSESSMENT PROTOCOLS

Introduction to Fitness Assessments

Go over the following test instructions with the whole class prior to beginning individual tests. Following these instructions, split the class into 3 groups and assign each group one test to begin at. Make sure to split students according to their assigned ID number (Ex – Students 1-5 at Vertical Jump, 6-10 at Cammy Handgrip, 11-15 at Takei Handgrip), and tell them to stay in ascending chronological order with the students around them (1, 2, 3, 4…). Once students complete a test, they can rotate the instructed direction to the next test, but again, must stay in ascending order.

Participant Instructions:

Vertical Jump Test-

Today you will be doing a vertical jump test to measure your lower body power. You will complete a total of 5 jumps- the first 2 will be practice jumps, and the last 3 will be real jumps.

Handgrip Strength Test-

Today you will be doing a handgrip strength test to measure your upper body strength. To do this, you will be using handgrip dynamometers- a handgrip dynamometer is a device that you squeeze as tightly as you can with your hand, and it analyzes how much force in kilograms (kg) your hand squeezed. You will perform this test 2 times with each hand, for a total of 4 attempts per dynamometer.
Handgrip Strength Protocol (Camry & Takeda)

Participant Instructions:
Go over with whole class prior to testing:

Today you will be doing a handgrip strength test to measure your upper body strength. To do this, you will be using handgrip dynamometers - a handgrip dynamometer is a device that you squeeze as tightly as you can with your hand, and it analyzes how much force in kilograms (kg) your hand squeezed. You will perform this test 2 times with each hand, for a total of 4 attempts per dynamometer.

Go over with groups prior to testing:

Demonstrate and instruct the protocol for the Handgrip Strength Test (using protocol in next section) to each group of students. Make sure you remember the first and last individual in each group that you go over instructions with so that you know the point at which you will need to re-instruct the next group with how they are to perform the test (students will be in numerical order, so simply put a small mark next to the first and last students in each group that has been present for instructions). Once students have completed the test, they may rotate to the next testing station.

Test Administrator Instructions for Handgrip Strength Test:

1. Settings - Make sure handgrip dynamometer grip size is set at the marked line, and that the measurements are being taken in kilograms (lbs).
2. Position - Student must have elbow fully extended (straight), hanging down at the side of their body, without touching the dynamometer to the body.
3. Measurement - Student gradually squeezes continuously for 2-3 seconds as forcefully as possible. Perform the test twice per hand, alternating between both hands, with a short rest between each measure. Write down the score of each attempt for each hand in kg on the Handgrip Score Chart for each student. Circle the best attempt for each student's hand.
Vertical Jump Protocol

Participant Instructions (Go over with whole class prior to testing):

Today you will be doing a vertical jump test to measure your lower body power. You will complete a total of 5 jumps— the first 2 will be practice jumps, and the last 3 will be real jumps.

Brief description of Vertical Jump Test:

1. Practice Jumps (Group): Demonstrate proper vertical jump test technique, then have entire class perform 2 practice jumps together for efficiency and assurance that all students have done them. It is important you make sure no students perform more or less than 2 practice jumps.
   a. Instructions for practice jumps are as follows:
      i. Hold a semi-squat position with arms downward and backward, pause momentarily in this position (about 1 second).
      ii. Jump as high as possible.
      iii. Rest 10-15 seconds between the 2 practice jumps.

2. Real Jumps (Individual): Have the individual student stand with feet flat on the ground, and reaching as high as possible using both arms with their hands crossed over each other above their head. Measure the highest point of the student’s standing reach (highest point of fingertips), set device so that the student’s highest point of their fingertips is just grazing the lowest vane (moveable slat).
   a. Instructions for real jumps are as follows:
      i. Face the device with dominant arm on the same side as the Vertical jump pole (bar).
      ii. Hold semi-squat position with arms downward and backward, pause in this position for about 1 second.
      iii. Jump as high as possible and push aside as many vanes as you can.
      iv. Rest 10-15 seconds between the 3 real jump attempts. Record each attempt on the Vertical Jump Score Chart, and then circle the highest attempt for each student.
      v. Once students have completed the test, they may rotate the instructed direction to the next testing station.
## APPENDIX F.  SAMPLE PROJECT SPREADSHEETS

### Iowa FitnessGram Evaluation: Teacher Spreadsheet

**School:** Sample School  
**Teacher:** Teacher X  
**Grade:** 6th  
**Class Time:** 9:00-10:00 AM  
**Group:** Sample 6th Group 1 (S6G1) - Red  
**Program:** Musculoskeletal

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## Camry Handgrip Strength Score Chart #1 (PRE)

**School:** Sample MS  
**Teacher:** Teacher X  
**Grade:** 6th  
**Class Time:** 9:00-10:45 AM  
**Group:** Sample 6th Group 1 (S6G1) - Red  
**Program:** Musculoskeletal

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APPENDIX G.  EXERCISE TASK CARDS

Original Set

Push-ups

Modification: Knee push-ups
Timing: Lower down (3 seconds), push-up (1 second)
Squat hold + Bicep curls
(Resistance band)

Timing: Curl up (2 seconds), lower (3 seconds)
Alternating back extensions
(Opposite arm with opposite leg)

**Timing:** Go up & hold (2 seconds), lower down (3 seconds), repeat on the other side
Reverse flies
(Resistance band)

Timing: Pull apart (2 seconds), hold (1 second), then bring back together (3 seconds)
Moving Plank
(Side to Side)

Timing: Plank walk left 3 steps, then switch right for 3 steps
Shoulder Press
(Resistance band)

**Timing:** Press up (2 seconds), hold (1 second), lower back down (3 seconds)
Burpees
(With push-up & no jump)

Modification: Knee push-ups
Timing: Get down into push-up position, lower down (3 seconds), push-up (1 second), stand up
Curl-ups

Timing: Curl up (2 seconds), lower down (3 seconds)
Chest flies
(Resistance band)

Timing: Pull together (2 seconds), hold (1 second), release back apart (3 seconds)
Alternating back extensions
(Both arms, both legs)

Timing: Go up & hold (2 seconds), lower down (3 seconds), then repeat on the other side
Side shoulder raise

(Resistance band)

**Timing:** Pull up (2 seconds), hold (1 second), lower back down (3 seconds)
Squat Jumps

**Timing:** Squat down (3 seconds), hold (1 second), jump up using arms
Forward-Backward line jumps

**Timing:** Jump with both feet forward & backward over the line as fast as you can
Side lunges

Timing: Lunge down to one side (3 seconds), hold (1 second), come up & lunge to other side
Burpees

(With jump, no push-up)

Timing: Go down into push-up position, hold (1 second), jump up as high as you can
Single-leg hops

**Timing:** Hop on 1 foot down the court, then switch & hop on the other foot back
Squats

**Timing:** Squat down (3 seconds), hold (1 second), stand back up (2 seconds)
180° squat hops

**Timing:** Squat down (3 seconds), hold (1 second), jump up & spin in the air, landing in the opposite direction
Side-to-side line jumps

**Timing:** Jump with both feet side to side over the line as fast as you can
Jumping lunges

**Timing:** Lunge down (3 seconds), hold (1 second), jump up, lunge to other side
Sprints
(Down & back)

Timing: Sprint down the court, jog back, repeat
Plank with shoulder touches

**Timing:** Touch one shoulder with opposite hand (2-3 seconds), then switch sides
Reverse planks

**Timing:** Keeping back & legs straight, hold.
Lunges

**Timing:** Lunge down (3 seconds), come back up (2 seconds); alternate legs.
Reverse Inchworm

**Timing:** Walk feet backward into plank (3 seconds), walk hands back to feet (3 seconds).
Moving Plank
(Side-to-Side)

Timing: Plank walk left 3 steps, then switch right for 3 steps
Lateral Shoulder Raise

(Resistance Band)

Timing: Pull up (2 seconds), hold (1 second), lower back down (3 seconds)
Lateral Line Jumps
(Side-to-Side)

**Timing:** Jump with both feet side to side over the line as fast as you can.
Sprints
(Down & Back)

Timing: Sprint down the court, jog back, repeat