ABSTRACT

Effectiveness of Lifetime Fitness Course Activities at Improving
Movement Efficiency through Fusionetics Movement Efficiency Test

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Exercise has lifelong benefits, specifically increased quality of life. University physical activity courses are designed to instruct on fundamental principles of exercise form and specific sports. Yet, in these courses there is a lack of evidence of improving movement efficiency (ME) that may highlight poor movement quality. The main purpose of this study was to determine how effective lifetime fitness (LF) activities at Baylor University are at improving ME. Eleven participants were recruited to perform a Fusionetics movement efficiency test at the beginning, middle, and end of the academic semester. Significance was found in overall ME scores from the pre and the post-test (pre 75.33 ± 6.34, post 70.69 ± 4.96). Within subgroups, a significant decrease was found between tests of the 2-leg squat (pre 78.786 ± 10.883, mid 89.19 ± 6.906) and the 1-leg squat (mid 47.72, post, 27.27). A significant increase was found between left (pre 54.55, mid 75.7) and right (pre 27.28, mid 60.6) hip symmetry. Future research should include a longer testing period to determine the effectiveness of ME testing detecting muscular or movement deficits in a sedentary university population.

Effectiveness of Lifetime Fitness Course Activities at Improving Movement Efficiency through Fusionetics Movement Efficiency Test

by

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A Thesis

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CHAPTER ONE

Introduction

Introduction

The benefits of exercise have been proven in multiple studies highlighting the increased quality of life from lifelong fitness (Ozturk & Unver, 2020; Nasui & Popescu, 2014). Benefits specifically for university students include sleep quality, mental health, and academic performance (Ozturk & Unver, 2020; Nasui & Popescu, 2014). Currently, 39% of university students are considered active according to the American College of Sports Medicine's (ACSM) criteria for active people (Ozturk & Unver, 2020;). The ACSM recommends either 150 minutes of moderate activity or 75 minutes of vigorous activity per week and participating in physical activity at least 3 days per week (Riebe et al., 2018). Unfortunately, statistics show that 61% of students are not meeting this criterion (Ozturk & Unver, 2020). The injury prevalence in physical education courses has been shown to be higher in adolescents (ages 13-17) than children (ages 8-12), with adolescents sustaining more severe injuries (Abernethy, 2003). One explanation for the higher injury risk in adolescence is a higher-performance concentration leading to stress-related injuries, growth plate injuries, and trauma injuries (Maffulli et al., 2010). Severe injuries have negative consequences later in life and may limit the ability to benefit from physical activity (Maffulli et al., 2010).

Screenings in the health care setting are used to identify a pathological condition that may cause an individual to become susceptible to injury prior to an individual's showing of the specific symptoms of that condition (Bahr, 2016). A movement screening is specifically designed to identify movement deficits that could impact injury (Bennett et al., 2020). The importance of early identification is to allow for intervention to mitigate the risk of the specific condition (Bennett et al., 2020). Some movement screenings that have been proven effective in athletic populations are both Functional Movement Screening (FMS) (Triplett et al., 2021) and Fusionetics (Quick-Royal, 2020; Cornell & Ebersole, 2018). Neither movement screening has been studied in sedentary university students. FMS, although effective for athletic populations, has conflicting evidence surrounding inactive populations, including the inability to distinguish between injured and non-injured individuals (Karuc et al., 2021). A meta-analysis on FMS effectiveness found poor sensitivity for athletes with a high injury risk while also reporting a limited predictive ability, concluding that FMS was not a valid test for predictive injury risk (Moore et al., 2019).

Fusionetics has been thoroughly tested as an intervention program in addition to a screening assessment (Quick-Royal, 2020). It has been proven effective in finding movement deficits in elite athletes, military and tactics, youth athletics, healthcare systems, and fitness communities (Quick-Royal, 2020). Fusionetics is a superior movement screening to FMS based on intra-rater reliability (Cornell & Ebersole, 2018). Research shows that 92% of individual movement compensations hold high intra-rater reliability (Cornell & Ebersole, 2018). Fusionetics also provides a solution to the concerns with injury predictive value associated with FMS (Bonazza et al., 2017).

Cornell and Ebersole (2018) suggest there are no consistent values, including optimized sensitivity, necessary to use as a cutoff point between injury risk and no risk within FMS. Fusionetics uses a scale of 1-100 instead of a scale of 0-21, used with FMS (Bonazza et al., 2017, Cornell & Ebersole, 2018). Although new, Fusionetics offers a more effective solution to detecting movement deficits in multiple populations compared to FMS.

Purpose

The purpose of this study was to determine if a Fusionetics Movement Efficiency Test could be used to determine the effectiveness of lifetime fitness (LF) course activities in sedentary university students. Specifically, the goal was to identify how effective activities in Fitness Theory and Practice (FTP) at Baylor university are at improving movement efficiency (ME) in a sedentary university population. A secondary purpose was to determine specific movement and muscular deficits in this population.

Hypotheses

Ho: There will be no significant difference in overall ME test scores between pre, mid, and post-test.

Ho: There will be no significant difference between the overall left and right symmetry.

Ho: There will be no significant difference in the leg ME tests scores between the pre, mid, and post-test.

Ho: There will be no significant difference between in symmetry ME test scores between left and right sides of the hop joint.

Delimitations

1. 3 males and 8 females for a total of 11 participants
2. Age: 18 years and older
3. Baylor students enrolled in FTP
4. Must complete FTP

Limitations

1. Participation in exercise more than 3 days of activity or 150 minutes of moderate activity per week (Riebe et al., 2018)
2. Musculoskeletal injury limiting activity in the past 5 years
3. Does not complete FTP course

Assumptions

All research team members will be adequately trained in all necessary study protocols.

CHAPTER TWO

Literature Review

Introduction

Movement efficiency assessments have been tested on multiple populations, including youth athletics, professional and college athletics, military and tactical skills, and healthcare or rehabilitation settings (Quick-Royal, 2020; Moore et al., 2019; Lopez-Valenciano et al., 2018; Pollen, Keitt, & Tojian, 2018; Bonazza et al., 2017). Yet, there is a gap in the literature concerning sedentary university students. A study on mortality rates and physical activity throughout life found a 29-36% lowered risk of all-cause mortality when participating in physical activity through adolescence into adulthood (Saint-Maurice et al., 2019). This finding explains a partial reasoning behind university major programs requiring at least 1 credit hour of physical activity to complete the degree. One beginning level course at Baylor University is FTP. The course contains a pre-fitness test that covers the cardiovascular endurance, muscular strength, and basic flexibility of the students (Ruckman, 2021). ME test add a component of the student’s movement that provides pertinent performance information to enhance not only learning, but also performance.

Current literature aims to examine ME at an elite, collegiate, or high school athletics and healthcare population. However, current research lacks the investigation of effectiveness of ME testing in a sedentary collegiate population. Karuc et al. (2021) suggests that FMS was unable to predict injury in adolescents but recommends future research in cross-validation with different ME assessments. Emery and Pasanen (2019) recommends examining educational settings. With supporting research proving improved movement quality with participation in multiple sports (Triplett et al., 2021) and evidence of ME assessment related to injury risk (Bennet et al., 2017), a sedentary population may benefit from ME testing in physical activity courses.

Purpose of Movement Screenings

Among various movement assessments, the primary goal is to guide safe and effective exercise prescription rather than highlighting injury risk (Bennett et al., 2020). The individualized exercise prescription allows for early intervention and therefore may mitigate the risk of further or new injuries (Bennett et al., 2020). Poor movement quality during strength training demands the need for movement screenings (Bennett et al., 2020) because in absence, it may lead to the development of undesirable motor patterns, muscular imbalances, and postural deviations (Bennett et al., 2020; Riebe et al., 2018) In the educational setting underdeveloped movement patterns support the need for a movement screening because students with multiple backgrounds ranging from beginner to self-taught to advanced are enrolled in the course. With a variety of backgrounds, students may have limited knowledge on correct movement forms, highlighting the need of a movement screening at the beginning of the course.

The optimal approach to sports injury prevention is modeled in 4 steps; (1) establish the extent of the injury, (2) Establish the mechanism of injury, (3) introduce a preventative measure, and (4) Assess effectiveness by repeating step 1 (Emery & Pasanen, 2019). In addition, behavior, defined as a controlled reaction driven by the intention to perform a specific behavior, may be considered a risk factor in the previous model (Verhagen et al., 2010). School settings are targeting these injury prevention strategies (Emery & Pasanen, 2019), therefore a useful setting for ME testing. The injury prevention model introduces the framework to fully understand injury prevention strategies, but ultimately the most useful assessment is the one that will continue to prevent injuries in athletes (Emery & Pasanen, 2019). This concept encourages ME testing to guide not only neuromuscular training, but instead specific behavior training (Verhagen et al., 2010). To prevent injuries in real-life situations, one must look beyond isolated injuries and focus on underlying factors to the student as a whole (Verhagen et al., 2010). Therefore, the purpose of movement screenings is to determine underlying factors of movement and muscular deficits that may aid in preventing future injury.

Screening for Exercise Prescription

To receive optimal benefits from physical activity, specifically resistance exercise, correct technique is necessary to achieve this outcome (Bennett et al., 2020). Technique will ensure the musculoskeletal system is safely loaded and the correct muscles, joints, and motor patterns are being trained (Bennett et al., 2020). Among inactive populations, a movement screening may provide pertinent information on how the student moves, therefore providing opportunities to improve their technique. The longer a student continues in a sedentary state following adolescent or high school sports, the weaker their motor function (Ge et al., 2021). Ge et al. (2021) using FMS shows that most students meet the minimum requirement for ME, but with small margin. Their study implies that future research should focus on improving these poor scores (Ge et al., 2021). The movement screening is also useful for intervention strategies. Exercise prescription can be personalized to the individual needs of the student in volume, load, and exercise selection. Movement screenings, when used appropriately, determine sites of muscular dysfunction (muscle weakness or neuromuscular imbalances), restrictions in joint mobility or excessive muscle tightness. Identifying areas of risk in student movement screenings will provide a measurement of movement quality and an improvement in training effectiveness (Bennett et al., 2020). Correcting movement quality has been proven effective in reducing injury (Cornell, 2016). The goal of ME testing in a sedentary population is to build a solid foundation of technique in movements outlined in ME assessments.

Some physical education courses use a pre and post fitness test to evaluate improvements in fitness levels. Specifically, Baylor's LF course, FTP, uses tests such as push-up to failure, 1 minute of sit-ups test, sit-and-reach test, and 1-mile Rockport walking test to assess student fitness (Ruckman, 2021) These tests measure upper body and core strength, hamstring and low back flexibility, and endurance, but not ME. The tests do not include any form or movement quality of any kind, allowing students to receive a higher score with poorer movement quality. Instructors may correct form through class periods, but an advantage of a movement assessment is a more reliable measure of taught ME (Bennett et al., 2020). Another advantage is instructors can clearly see which movements are misunderstood in a practical and applicable measurement, to enhance the student’s experience in the fitness course and the instructor’s teaching. A final strength is that once the foundation of movement quality is established, instructors can then challenge students by adding variations of movements to increase strength and capacity (Bennett et al., 2020). It has been proven that by improving movement quality, performance is enhanced (Chapman et al., 2014). Long-term functional and performance outcomes will be increased by using a movement screening to enhance movement quality in physical education courses (Bennett et al., 2020).

Movement Screening Requirements

Two of the primary purposes for movement screenings are to evaluating movement quality and to develop exercise prescription (Bahr, 2016). Many variations of movement screenings have been created for these specific purposes. The two most popular movement screenings currently are FMS and Fusionetics. There are three key principles to consider for a movement screening; (a) strong association between a marker from a screening test and injury risk, (b) test properties must investigate in relevant populations with appropriate statistics, and (c) integration of an intervention program structured to improve movement deficits found in the screening (Bahr, 2016). A strong association between a marker from a screening test and injury risk is necessary to determine whether the screening is accurate (Bahr, 2016). These strong associations are necessary to provide accuracy in identifying muscular and movement deficits (Bahr, 2016). Without these three necessary components, movement screenings are incapable of accurately providing information on movement efficiency.

Functional Movement Screening

FMS is the most common injury assessment thus far. The assessment has been proven effective in identifying at risk athletes in professional, collegiate, and youth athletics through determined movement compensations correlated to injury (Lopez-Valenciano et al., 2018; Pollen et al., 2018; Bonazza et al., 2017). FMS is considered most effective for college populations who perform multiple sports (Moore et al., 2019). Therefore, FMS can also be effective in a physical activity course as it involves a variety of activities, sports, and games. The test is composed of seven movement tests designed to observe performance of basic locomotor, manipulative, and stabilizing movements. The test focuses on identifying weaknesses and imbalances of stability and mobility (Cook et al., 2014). The intended purposes are to identify at risk individuals, systemically correct and improve fundamental movement patterns, monitor progress and development in the presence of injury and fitness level and create a functional movement baseline for statistical observation (Cook et al., 2014). The test begins with the deep squat, measuring bilateral, symmetrical, and functional mobility of the hips, knees, and ankles (McCunn et al., 2016). It also assesses bilateral and symmetrical mobility of the shoulders by holding a dowel overhead (Cook et al., 2014). The second test is the hurdle step challenging the body’s proper stride mechanics, requiring proper coordination and stability of the hips and torso (Cook et al., 2014). The test also includes single leg stance ability, assessing bilateral functional mobility and stability of the hips, knees, and ankles (Cook et al., 2014). The in-line lunge is an attempt to place the body in a stimulated stressed position to assess hip and ankle mobility and stability, quadriceps flexibility, and knee stability (Cook et al., 2014). Shoulder mobility is used to assess bilateral and reciprocal shoulder range of motion, combining internal rotation with adduction and external rotations with abduction. Finally, assessing normal scapular mobility and thoracic spine extension (Cook et al., 2014). The active straight leg raise is used to determine the ability to disassociate the lower extremity from the trunk, while maintaining stability in the torso (Cook et al., 2014). Specifically, active hamstring and gastro-soleus flexibility with stability in pelvis and core. Next, the trunk stability push-up is used to test the ability of trunk stability in the sagittal plane with a symmetrical upper extremity push-up (Cook et al., 2014). Finally, rotary stability is used to challenge proper neuromuscular coordination and energy transfer from one body segment to another through the torso. Measuring multi-planar trunk stability during combined upper and lower extremity motion (Cook et al., 2014).

Scoring of the test involves scoring of each subdivision ranging from zero to three, with three being the highest possible score (Cook et al., 2014). A score of zero is given if any pain is experienced during the movement (Cook et al., 2014). A score of one is given to those who cannot complete or assume the movement position (Cook et al., 2014). A score of two is given if the movement is incorrectly completed but requires compensation and a score of three is given when the movement is correctly completed without compensation (Cook et al., 2014). scores are documented on both the right and left sides to identify symmetry (Cook et al., 2014). The highest possible total score is twenty-one and is scored on the minimal standard, not “perfect” movement (Cook et al., 2014). The scoring is to be used to statistically compare areas of movement concern throughout intervention/ training programs (Cook et al., 2014).

A key concept to understand from this test is the meaning of the test title. The function is representing the absence of dysfunction with movement quality. The movement designates what the test is measuring and screen to discern risk of injury. The screening is meant to be used to determine and identify at risk areas and levels of competency.

Limitations of Functional Movement Screening

Although FMS is one of the most well-known movement screenings, it includes limitations. In a meta-analysis on sporting populations, there was a significant relationship between the number of sports played during high school and the FMS score (Triplett et al., 2021). The greater number of sport participation, the higher the FMS score, indicating the increased movement variety directly relates to total scores and asymmetries (Triplett et al., 2021). The relation between higher total scores and asymmetries suggests that FMS cannot be used for sport specific movements or indicate specific injuries. Research on FMS has been advocated to understand why injuries happen and to determine which participants are at risk for an injury (Bahr, 2016). Yet, a study done on adolescents using FMS with machine learning strongly suggest that FMS is not valuable for an average adolescent population with an average age of 16.6 (Karuc et al., 2021). The predictive value of FMS has been undermined in multiple populations including athletes, college students, and adults (Triplett et al., 2021, Moore et al., 2019; Pollen et al., 2018), in some cases even finding a higher risk after performing FMS (Bennett et al., 2020). Criteria for movement screenings require accurate measurements in multiple populations. FMS has been tested in elite athletes, collegiate athletes, and adolescents with inconclusive effectiveness (Pollen et al., 2018). FMS composite scores do not vary despite differences in age and proficiency of sport, even with reportedly differing injury rates (Pollen et al., 2018). High school athletes on average score lower than elite athletes, with less injuries occurring in high school athletics than elite athletics (Pollen et al., 2018). Instead of correlating lower FMS composite scores with increased injury rates, the higher FMS scores found correlation with increased injury rates, an inverse relationship to that which was expected (Pollen et al., 2018). FMS, although popular, is not an accurate measurement of injury prediction.

Fusionetics

Fusionetics ME test is a novel and upcoming assessment. Like FMS, Fusionetics focuses on seven different movements including four separate areas of focus (Lower body, upper body, cervical, and trunk/ lumbar) (Cornell & Ebersole, 2018; Eckard et al., 2018). The seven movements include a double-leg squat, double leg squat with heel lift, single leg squat, push-up, shoulder motions, cervical spine motions, and trunk/lumbar motions (Cornell & Ebersole, 2018; Eckard et al., 2018). The test is scored by assessing individual movements and providing a score from 1-100. The scores are deducted if compensations are used during specific movements (Cornell & Ebersole, 2018; Eckard et al., 2018). This screening is proven to overcome limitations suggested from FMS such as targeting corrective movements in training programming (Cornell & Ebersole, 2018). Another strength is the increased sensitivity of the test by expanding the scoring from the total score of twenty-one used in FMS to a scale of 0-100 used in Fusionetics (Cornell & Ebersole, 2018; Eckard et al., 2018). This expansion allows for the assessment to target specific deficits in functional movement quality to use corrective exercise intervention (Cornell & Ebersole, 2018; Eckard et al., 2018). The assessment is also recommended for "excellent" inter-rater reliability for movement quality (Pollen et al, 2018). Fusionetics is best used for rehabilitation purposes, finding strength in identifying movement quality improvements (Harris et al., 2019). This screening is still a new test and requires more research to determine its practicality in educational purposes (Eckard et al., 2018).

CHAPTER THREE

Methods

Participants

There were 13 total participants in the study (10 females and 3 males). One participant dropped out from a non-sports related injury, not associated with the study, and another dropped out from incompletion of FTP, finishing with a total of 11 participants (8 females and 3 males). Participants were sedentary young adults between the ages of 18 and 22 enrolled in Baylor University's LF course, FTP. Participants were recruited in the first week of classes via class visits. All participants signed an informed consent form and inclusion/ exclusion criteria form that had been approved by the Baylor University Institutional Review Board for the Protection of Human Subjects in Research. All interested participants met the following criteria.

- Baylor students enrolled in FTP
- Age 18 and over
- Must Complete FTP
- Does not exercise more than 3 days or 150 minutes of moderate to vigorous activity per week (Riebe et al., 2018)
- No musculoskeletal injury limiting movement in the past 5 years

Study Sites

All data collection and participant sessions took place in the weight room in Russell Gym at Baylor University, Waco, TX.

Variables

The independent variables were the timing of the test (pre, mid, and post-test) and symmetry (left and right). The dependent variable was the ME score.

Fusionetics Movement Efficiency Test

The test was administered according to the guidelines provided by Fusionetics, LLC (Table 3.1). All participants performed the screening in athletic apparel. Athletic apparel includes a loose shirt, athletic shorts, and no shoes. Each screening was performed in the following order: 2-leg squat, 2-leg squat with heel lift, 1-leg squat, push-up, shoulder movements, trunk movements, and cervical movements (see Table 3.1). Each participant completed 5 reps of the 2-leg squat, 2-leg squat with heel lift, 1-leg squat, and push-up each sub-test. Any observed compensations were recorded for scoring purposes. The shoulder movements, trunk and lumbar spine movements, and cervical movements were performed once for each movement and recorded any observed compensations for scoring purposes.

ME Test Scoring

When scoring the Fusionetics ME test, the final score is the average of all subgroup scores out of 100. Each subgroup has a list of compensations to observe, and the score is decreased based on compensations detected during the subgroup test. The instructions for all subgroups are described in Table 3.1.

Table 3.1.

Fusionetics Movement Efficiency Test Guidelines

Sub-Tests	Participant Positioning	Tester Instructions/ Participant Actions
2-Leg Squat	Feet shoulder-width apart Toes pointing straight ahead	Perform 5 squats as if sitting into chair Observe: Front, side, and back views
2-Leg Squat with Heel Lift	Elevate heels approximately 2” Feet shoulder-width apart Toes pointed straight ahead	Perform 5 squats as if sitting into chair Observe: Front, side, and back views
1-Leg Squat (Completed bilaterally)	Balancing on 1-leg, with hands on hips Toes pointing straight ahead Non-involved foot and leg are neutral	Perform 5 squats as if sitting into chair Observe: Front, side, and back views
Push-up	Assume a push-up position Hands outside shoulder, even with chest Head looking at ground, cervical spine at neutral	Perform 5 push-ups Observe: Side view
Shoulder Movements (4 total movements completed bilaterally)	Standing with back to wall Feet hip-width apart, arms by sides Heels, buttocks, shoulders, and back of head touching wall	1. Flexion: Raise arms straight overhead, touch thumb to wall 2. Internal rotation: Elbows at 90, rotate shoulder taking wrists forward toward mid-line of body 3. External rotation: Elbows at 90, rotate shoulder taking back of wrist to wall 4. Horizontal abduction: hands together in front of body, reach back of wrist to wall All of the above: Observe front and side views, perform one arm at a time
Trunk Movements (2 total movements completed bilaterally)	Standing with back to wall Feet shoulder-width apart, arms by sides Heels, buttocks, shoulders, and back of head touching wall Rotation: Individual steps away from wall, places hands across shoulders	1. Lateral flexion: side bend and slide hand down outside of leg to lateral knee joint line 2. Rotation: Rotate upper body (maintaining a neural pelvis/ hips) each direction as far as possible) All of the above: Observe front and side views; perform movement in each direction
Cervical Movements (2 total movements completed bilaterally)	Feet shoulder-width apart, arms by sides Head in neutral position	1. Lateral flexion: Tip head, taking ear to shoulder 2. Rotation: Rotate head and look over shoulder All of the above: Observe front and side views; Perform movement in each direction

2-Leg Squat Compensations

For the 2-leg squat, there are three different views and ten different possible compensations to look for. Within the foot and ankle, the compensations are either the foot turns out or flattens. This is viewed from the front. The foot turning out is defined as any lateral deviation from the starting position. The flattened foot would occur if the lateral aspect of the foot lifts off the floor. The next compensations involve either varus or valgus of the knee. The criterion for the knee valgus is the mid-patella moving inside the big toe. For knee varus, the criterion is the knee is outside of the fifth metatarsal. The second view is from the side/ lateral view. The first potential compensation is excessive forward trunk lean. This is characterized by the inability for the participant to keep the torso and lower leg parallel through the motion of the squat. Another compensation is the low back arch or low back round. The low back arch is characterized by any movement into lumbar extension from the starting position. The low back round is defined as an increased lumbar flexion or posterior pelvic tilt prior to 90 degrees of hip flexion. The final view is from the rear. The two compensations from this view are asymmetrical weight shift and heel lifting. The heel lifting compensation is when there is visible space between the calcaneus and the floor. The asymmetrical weight shift is characterized as the gross movement of the squat. Whichever side the weight is shifting to, is where the compensation would be recorded.

2-Leg Squat with Heel Lift Compensations

For the 2-leg squat with heel lift, the compensation criterion is the same as the 2-leg squat. The only compensation that is not included is the heel of the foot lifting.

1-Leg Squat Compensations

The 1-leg squat is observed only in the front view. The first possible compensation is the foot flattening. The flattened foot is occurring when the lateral aspect of the foot lifts off the floor. Similar to the 2-leg squat and 2-leg squat with heel lift, the next two compensation are knee valgus and varus. The criterion for knee valgus is the mid-patella moving inside the big toe. For knee varus, the criterion is the knee is outside the fifth metatarsal. Finally, specific to the 1-leg squat, the compensations are an uncontrolled trunk including flexion, rotation, and/ or hip shift. This first noticeable movement is a lateral hip shift. This is separate from a valgus movement in the knee. Additional movements could be movement (either towards or away) of the torso in the transverse plane. Finally, another movement could potentially be excessive forward migration of the trunk. This is characterized by the inability for the participant to keep the torso and lower leg parallel through the motion of the squat. Finally, the final compensation is the loss of balance. This can be characterized by the hands coming off the hips or repeated touching of the non-stance foot on the floor at least two or more times.

Push-up Compensations

There are four separate compensations for the push-up. The first observed compensation is the knees bend compensation. This is if the participant is not able to perform all repetitions on their toes. If the participant chooses to perform all repetitions on their toes and the knees bend towards the ground, it will be recorded as a compensation. The second compensation is the head moving forward. This is defined as any deviation from the starting position including the head moving into hyperextension, or head dropping towards the floor. The next compensation is scapular winging. This is looking for the medial or inferior aspects of the scapula are elevating from the ribcage or if there is any asymmetrical movement of the scapula. If there is more than one fingers-breath off the ribcage. Finally, low back arching or stomach protruding is the final potential compensation.

Shoulder Movement (4 total) Compensations

The shoulder movement has four separate movement patterns: flexion, internal rotation, external rotation, and horizontal abduction. The common compensation for shoulder flexion is elbow flexion. The elbow must be locked out during the motion. Another potential compensation is excessive or early shrugging/ elevation of the shoulder. Finally, the low back may arch, or ribcage may flare increasing space between the pelvis and the ribcage. The second movement is shoulder internal rotation. The goal is to reach the wrist in line medially with the ribcage. A common compensation is anterior tipping of the scapula to compensate for not reaching the full rotation. The third movement is external rotation. This is the opposite movement of internal rotation, and the participant is attempting to touch the back of the wrist to the wall. The compensations are an inability to reach the wall with a straight wrist and may reach their fingers towards the wall. Another compensation is a shrugging of the shoulders or rib flare to attempt the reach their hand back. The final movement is horizontal abduction. A compensation is the inability to touch the back of hand to wall, elevating or deviation above the shoulder, bending of the elbow and finally, rotation of the trunk towards the side of rotation.

Trunk and Lumbar Spine Movement (2 total) Compensations

The trunk and lumbar spine movements are trunk lateral flexion and trunk rotation. For trunk lateral flexion the potential compensations are the inability to complete the movement, any movement outside of the frontal plane including leaning forward or backwards. Finally, any hip shifting or movement of the opposite foot to complete the movement. When complete, trunk rotation compensations are the inability to complete the movement, any movement outside of the trunk to assist with the rotation, and any movement outside of the transverse plane.

Cervical Movements (2 total) Compensations

The two cervical motions are cervical lateral flexion and cervical rotation. Compensations for lateral flexion is the inability to reach approximately 45 degrees of flexion. Other compensations are any accessory movement of the head and neck outside of the frontal plane or shoulder shrugging. Compensations for cervical rotation are again inability to complete the movement defined as the lateral side of the mouth reaching the line of the anterior aspect of the shoulder. Other compensations are excessive flexion of the head or head extension.

Testing Visits

For the pre-test, participants were tested on the second-class day, before they had participated in activity for the class. Participants were instructed to wear comfortable athletic clothing and shoes. During this session the demographics sheet and consent form were filled out. Each participant was given instructions on how to perform each subgroup test and then allowed to try the movements prior to the observation period. Each test was observed by one rater, trained through Fusionetics to properly administer the ME test. The full timeline can be viewed in Table 3.2.

The mid-test was performed following the fourth rotation. The test (Table 3.1) was performed in the same format as the pre-test. All tests were performed prior to class activity. The total time for the mid-test was 15 minutes.

The post-test was performed following the seventh total rotation. Prior to the ME test, participants were asked to fill out a self-injury report (See Appendix A). See a full timeline in Table 3.2. The report was a general injury report that may have occurred over the entire semester. The report included questions on participation, modified training, performance, and symptoms for the lower body (hips, knees, ankles, feet, and toes), upper body (shoulders, elbows, wrists, and fingers), trunk (high/low back, abdominals, and chest) and cervical (head and neck) (Clarsen et al., 2020). Following the completion of the self-injury report, participants performed the final ME test. The same format and the prior two ME session was used. No class activity was performed prior to the testing session.

Table 3.2.

Testing Timeline

Pre-Test Visit	Mid-Test	Post-Test
Documentation -Consent Form -Demographics Form Fusionetics Pre-Test	Fusionetics Mid-Test	Participant Self-Injury Report Fusionetics Post-Test

Note: Each test was approximately 15-20 min.

FTP Activities

All activities in FTP were done in a rotation between an aerobic activity, strength activity, and game (Table 3.3). Following the pre-test, all classes participated in four different rotations including all three of the different activities. Following the fourth rotation, students completed the mid-test to measure effectiveness of activities in improving ME.

The second half of the FTP course followed the same rotation format as the first half. The second half of the semester contains three rotations of activities because there is an odd number of rotations that lines up with the weeks in the semester. Following the third rotation of the second half, the post-test was performed. All activities can be viewed in Table 3.4.

Table 3.3.

Rotations/ Activities for the First Half of FTP

Aerobic	Strength	Game/ Activity
Target Tabata	Agility Bootcamp	Team Handball with Scooters
Cardio Relays	Weight Room Etiquette	Floor Hockey
Rah Rah Hepa (Soccer)	Kettlebell and Dumbbell Workout	Secret Agent Tag
Spartan Adventure Race	Functional Fitness Workout	Kin Ball Games

Table 3.4.

Rotations/ Activities for the Second Half of FTP

Aerobic	**Strength**	**Game/ Activity**
Aerobic Bootcamp	Weight Room Workout	Team Handball
Free Cardio Day	Bands and Bodyweight Stations	Ultimate Frisbee
Baylor Scavenger Hunt	Power Yoga	Kickball

Data Collection

Data collection occurred in three separate sessions. The inclusion/ exclusion criteria form was given prior to the first session. During the first session, participants completed the informed consent form, demographic form including age, gender, height, and weight and the ME test. This test took place prior to the pre-testing session of the class. At each following session they performed the same ME test. At the final session, participants completed the self-injury report (Clarsen et al., 2020) before they performed the same ME test as the prior two sessions. The self-injury report can be found in appendix A. The self-injury report has been reported with high internal consistency proven through a Chronbach's α of 0.91 (Clarsen et al., 2013). The test was also considered valid (Jorgenson et al., 2016) and allows for appropriate severity tested through multiple studies (Jorgenson et al., 2016; Clarsen et al., 2013).

Statistical Analysis

All statistical analysis was performed in SPSS 28. An analysis of variance (ANOVA) with repeated measures on the test was performed on all ME and subgroups. A two-way ANOVA with repeated measures was performed on the symmetry scores.

Descriptive statistics were also measured on all overall ME scores, subgroups, and symmetry scores. Means were considered significantly different when the probability of a type I error was .05 or less.   If the sphericity assumption was violated, Huynh-Feldt corrections for the *p*-values were reported. Partial eta-squared (η_p^2) values were computed to determine the proportion of total variability attributable to each factor or combination of factors. With a moderate effect size of 0.5, two-sided alpha of 0.05, the estimated sample size was 10 for 80% power and 13 for 90% power.

CHAPTER FOUR

Results

Participant Characteristics

The participants recruited for this study were sedentary students for a minimum of three months as defined by ACSM (Riebe et al., 2018). All participants were recruited from Baylor University's LF course, FTP. In total, the study included 13 participants. One participant was removed for not completing the FTP course and another participant was removed for a non-sports injury unrelated to the study. Of these 11 participants, 3 were men and 8 were women. The baseline anthropometric data describing the 11 participants who completed the study is in Table 4.1.

Table 4.1.

Group Specific Participant Baseline Characteristics.

Participant Baseline Characteristics	Men	Women
Sample Size (n)	3	8
Age (years)	18.33 ± 0.577	20.13 ± 1.55
Height (cm)	180.67 ± 1.15	163.25 ± 4.2
Body Weight (kg)	73 ± 24.88	63.75 ± 15.42

Note: cm = centimeters; kg = kilograms

Overall ME Score

Fusionetics ME test is scored on a scale from 1-100 and each score is classified as good (75-100), moderate (50-74.99) or poor (0-49.99). The pre and mid-test averages for the overall ME score were classified as good (pre 75.33 ± 6.34, mid 79.87 ± 8.22), and the post-test average was in the moderate category (post 70.69 ± 4.96). These results are illustrated in Figure 4.1 and Table 4.1. There was statistically significant effect found on tests (F = 4.764, $P = 0.020$, $\eta_p^2 = 0.323$). The pre and mid-tests were higher than the post-test ($P < 0.05$). These results are also shown in Table 4.2.

The overall ME score averages increased by 1.12% from the pre to the mid-test. From the mid to the post-test, the average test difference was -7.82%. Overall, from the pre to the post-test, the difference was -6.56%. These results are represented in Table 4.4 and illustrated in Figure 4.2.

There was no statistically significant effect on the overall ME symmetry scores for the sides (F = 4.306, $P = 0.065$, $\eta_p^2 = 0.301$). There was a statistically significant effect on the tests (F = 4.317, $P = 0.028$, $\eta_p^2 = 0.302$). Finally, there was no statistically significant effect on the interaction between sides and tests (F = 0.710, $P = 0.504$, $\eta_p^2 = 0.066$). These results can be viewed in Table 4.3.

Table 4.2.

One-Way ANOVA of Overall ME Scores

Mean ± SD			SS	df	MS	*F*	*p*	Eta Sq
Pre	Mid	Post						
75.33 ± 6.34	76.2 ± 5.14	70.69 ± 4.96	194.158	2	97.079	4.764	0.020*	0.323

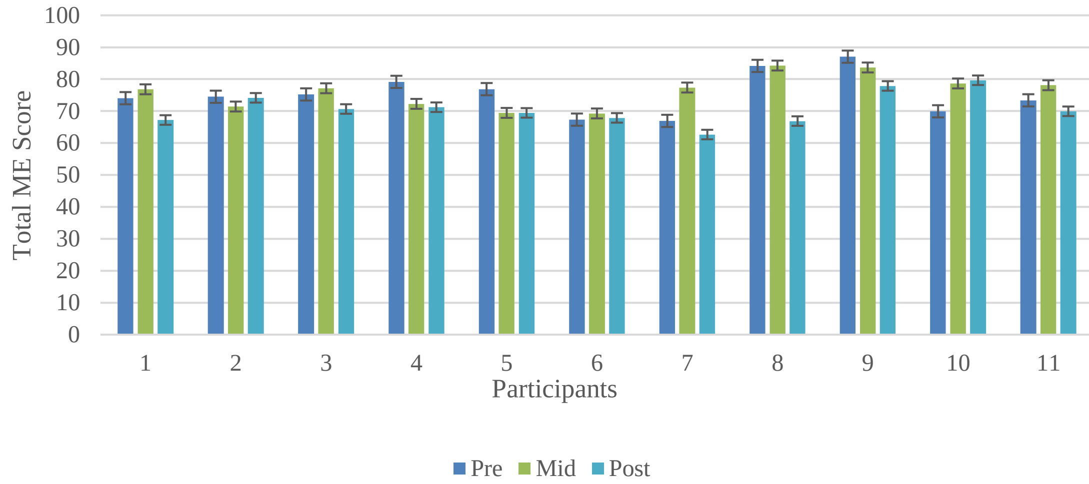

Figure 4.1. Comparison of Overall ME Test Scores

Table 4.3.

Overall ME Symmetry Between Left and Right

Variable	Source	SS	df	MS	*F*	*p*	Eta Sq
	Side	178.6	1	178.56	4.306	0.065	0.301
Symmetry	Test	440.153	2	220.08	4.317	0.028*	0.302
	Side * test	47.306	2	23.653	0.710	0.504	0.066

Table 4.4

Percentage of Change Between Tests

Test	Percentage of Change
Pre to Mid-Test	1.17%
Mid to Post-Test	-7.82%
Pre to Post-Test	-6.56%

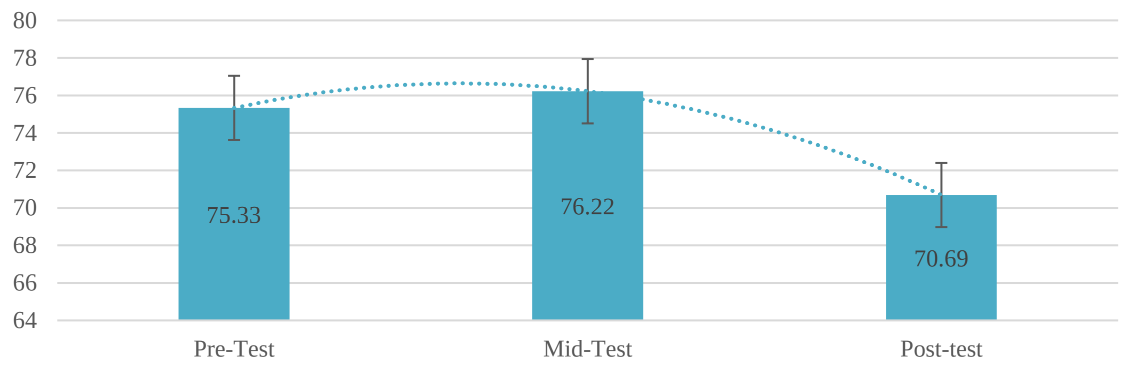

Figure 4.2. Percentage of Change Between Overall ME Test Score Averages
Note: The trendline represents the percentage of change between tests.

Overall ME Subgroup Data

Data related to ME subgroup divisions was analyzed using a one-way ANOVA with repeated measures. Significant effects were found on the 2-Leg Squat (F = 3.849, *P* = 0.039, η_p^2 = 0.278) and the 1-Leg Squat (F = 7.441, *P* = 0.004, η_p^2 = 0.427). A graph displaying the mean values and standard deviation results is shown below in Figure 4.3. ANOVA results for all movement subgroups are shown below in Table 4.5.

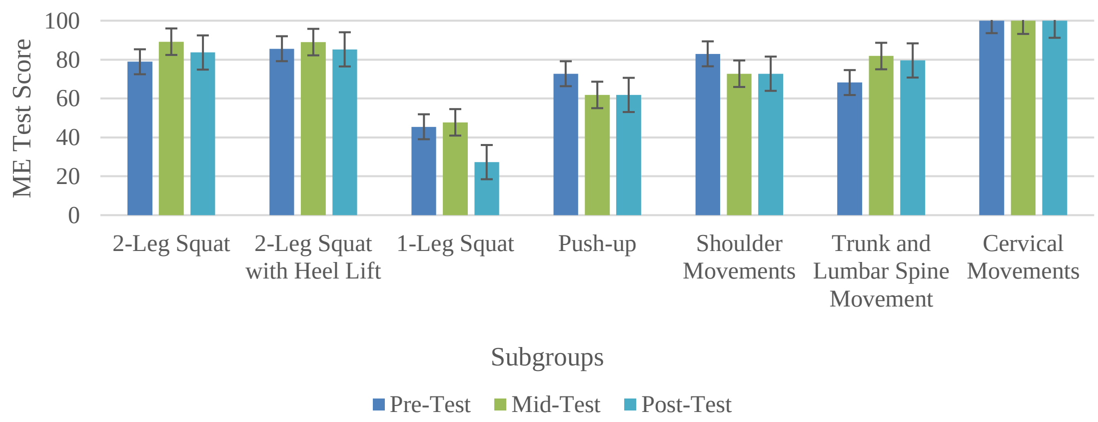

Figure 4.3. Overall Subgroup Division Between All Tests

Table 4.5.

Subgroup One-Way ANOVA with Repeated Measures Results

Subgroup	SS	df	MS	*F*	*p*	Eta Sq
2-Leg Squat	596.32	2	298.16	3.849	0.039*	0.278
2-Leg Squat with Heel Lift	92.645	2	46.322	0.752	0.484	0.070
1-Leg Squat	2765.3	2	1382.65	7.441	0.004*	0.427
Push-Up	872.727	2	436.364	1.440	0.260	0.126
Shoulder Movements	767.045	2	383.523	2.404	0.116	0.194
Trunk/ Lumbar Spine Movements	1174.242	2	587.121	1.270	0.302	0.113
Cervical Movements	0	2	0	-	-	-

2-Leg Squat

Within the 2-leg squat the variance between tests was statistically significant (F = 3.849, P = 0.039, η_p^2 = 0.278). The mid-test was higher than the pre-test ($P < 0.05$). The mean score increased from the pre to the mid-test (pre 78.786 ± 10.883, mid 89.19 ± 6.906) and decreased from the mid to the post-test (post, 83.635 ± 11.802). ME scores of the test for the 2-leg squat are shown in Figure 4.4.

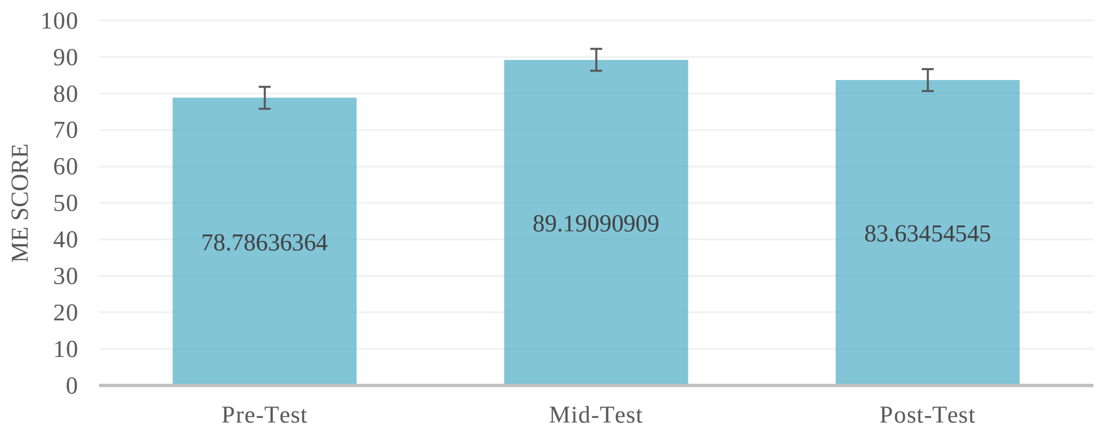

Figure 4.4. Mean Participant 2-Leg Squat Scores

2-Leg Squat with Heel Lift

Within the 2-leg squat with heel lift, there was no statistically significant effects on the tests (F = 0.752, P = 0.484, η_p^2 = 0.07). The mean score slightly increased from the pre to the mid-test (pre 88.588 ± 8.736, mid 88.989 ± 5.845) and slightly decreased from the mid to the post-test (post 85.251 ± 7.982). ME scores of the test for the 2-leg squat with heel lift are shown in Figure 4.5.

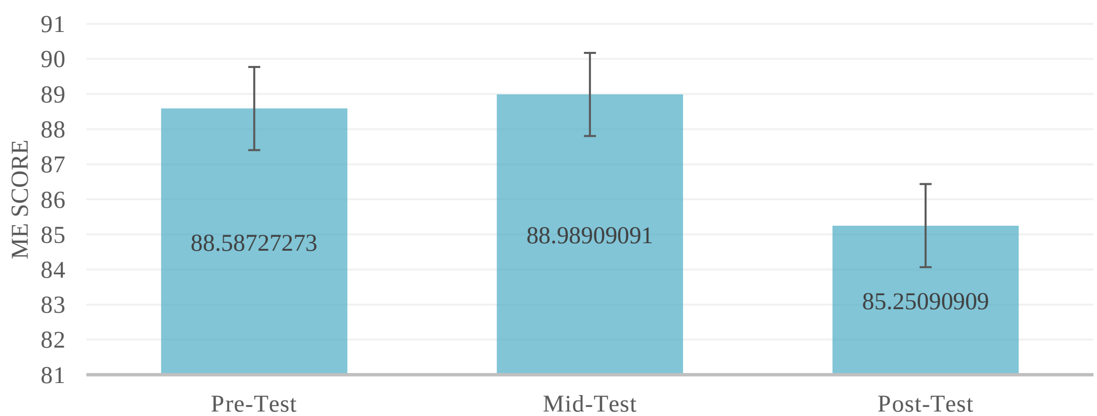

Figure 4.5. Mean Participant 2-Leg Squat with Heel Lift Scores.

1-leg Squat

With the 1-leg squat, there was a statistically significant effect on the tests (F= 7.441, P = 0.010, η_p^2 = 0.427). The pre and mid-tests were higher than the post-test (P < 0.05). There was a slight increase from the average of the pre to the mid-test (pre 45.451 ± 9.402, mid 47.725 ± 12.411), and a decrease from the mid to the post-test (post, 27.269 ± 17.908). ME scores of the test for the 1-leg squat are shown in Figure 4.6.

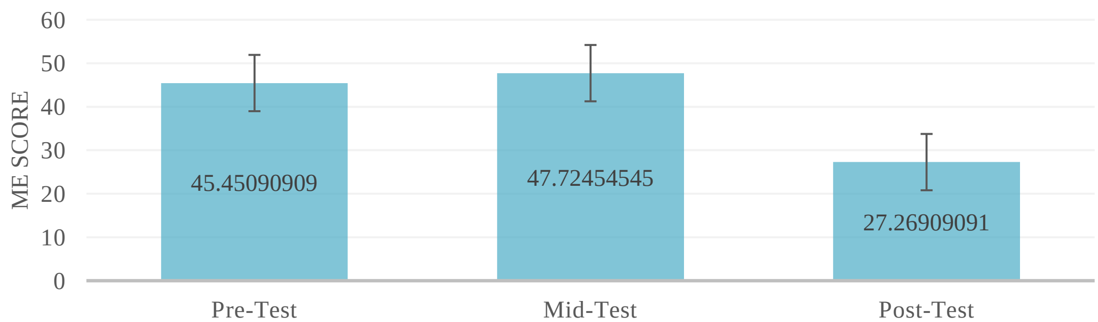

Figure 4.6. Mean Participant 1-Leg Squat Scores

Push-Up

With the push-up, there were no statistically significant effects on the tests (F= 1.440, P = 0.260, η_p^2 = 0.126). There was a decrease from the pre to the mid-test (pre 72.727 ± 25.725, mid 61.818 ± 22.724) and no change from the mid to the post-test (post 61.818 ± 26.007). ME scores of the test for the push-up are shown in Figure 4.7.

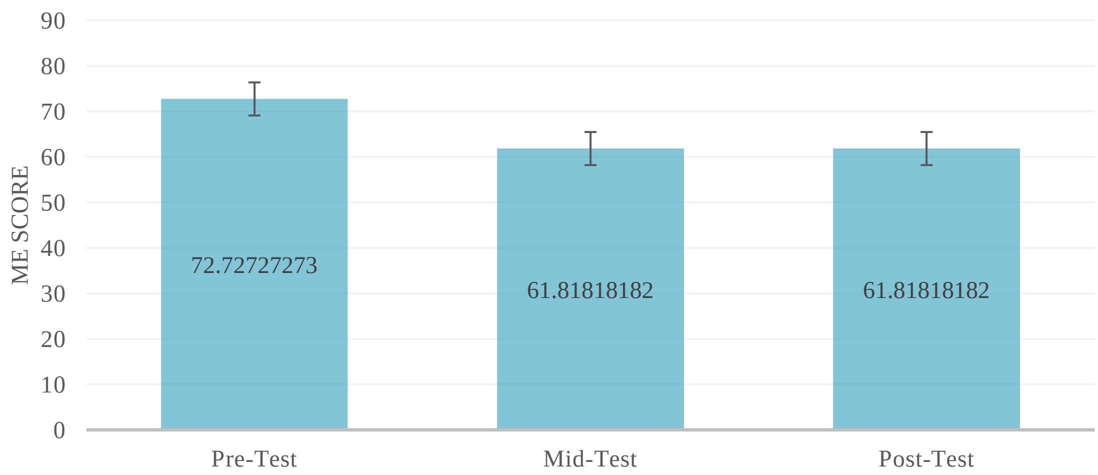

Figure 4.7. Mean Participant Push-up Scores.

Shoulder Movements (4 Total)

For the shoulder movements, there were no statistically significant effects on the tests (F= 2.404, P = 0.116, η_p^2 = 0.194). There was a slight decrease from the pre to the mid-test (pre 82.955 ± 16.079, mid 72.727 ± 16.6) and no change from the mid to post-test (post 72.727 ± 14.597). ME scores of the test for the shoulder movements are shown in Figure 4.8.

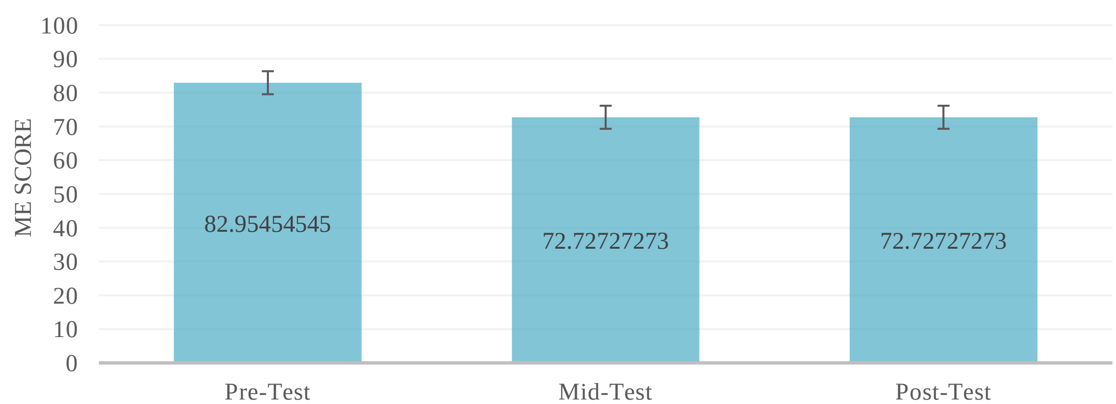

Figure 4.8. Mean Participant Shoulder Movement Scores.

Trunk/ Lumbar Spine Movements (2 Total)

For the trunk and lumbar spine movements, there were no statistically significant effects on the tests (F = 1.27, P = 0.302, η_p^2 = 0.113). There was an increase from the pre to the mid-test (pre 68.182 ± 25.226, mid 81.818 ± 25.226) and a slight decrease from the mid to the post-test (post 79.546 ± 24.541). ME scores of the test for the trunk and lumbar spine movements are shown in Figure 4.9.

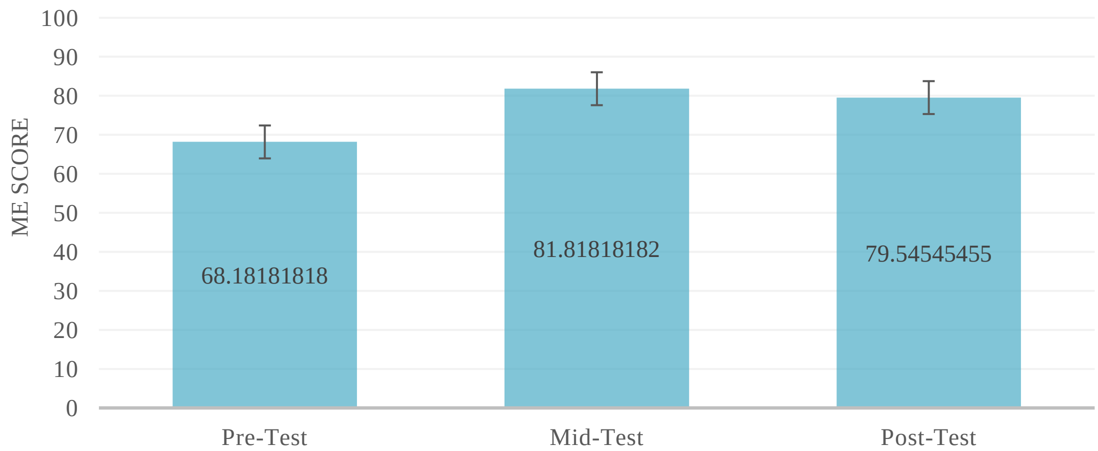

Figure 4.9. Mean Participant Trunk and Lumbar Spine Movement Scores.

Cervical Movements (2 Total)

For the cervical spine movements, there were no statistically significant effects on the tests (F = 0, P = 1, η_p^2 = 0). Overall, all scores were the same for all three tests. ME scores of the test for the cervical spine movements are shown in Figure 4.10.

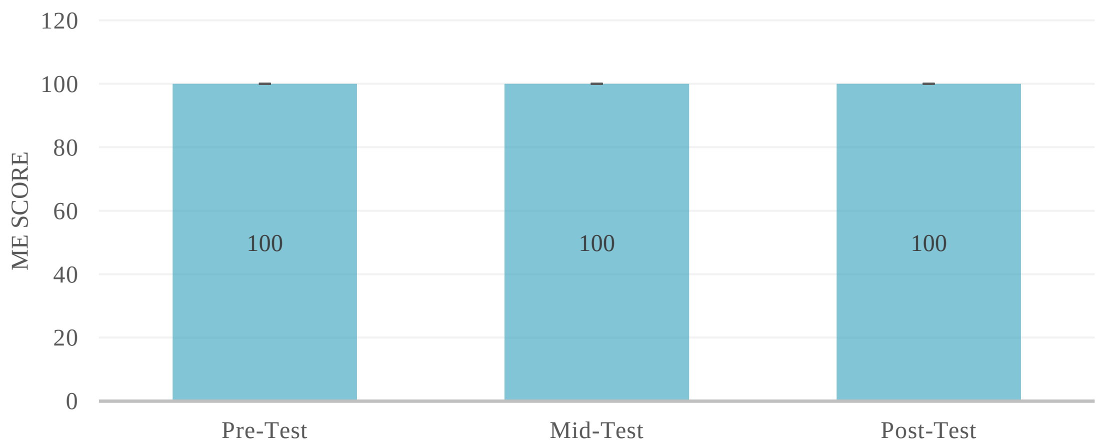

Figure 4.10. Mean Participant Cervical Spine Movement Scores

Subgroup Symmetry Scores

Data related to subgroup symmetry scores was analyzed using a two-way (Side x Test) ANOVA with repeated measures. Significant effects were found only on side for the hip joint (F = 9.164, $P = 0.013$, $\eta_p^2 = 0.478$). There was no effect on symmetry for the neck/ cervical spine, shoulder, trunk/lumbar spine, foot/ankle ($p > .05$), there was no main effect on test and no interaction between side and test ($p > .05$). This is illustrated below in Figure 4.11. Two-way ANOVA with repeated measures results on 6 joints are shown in Table 4.6.

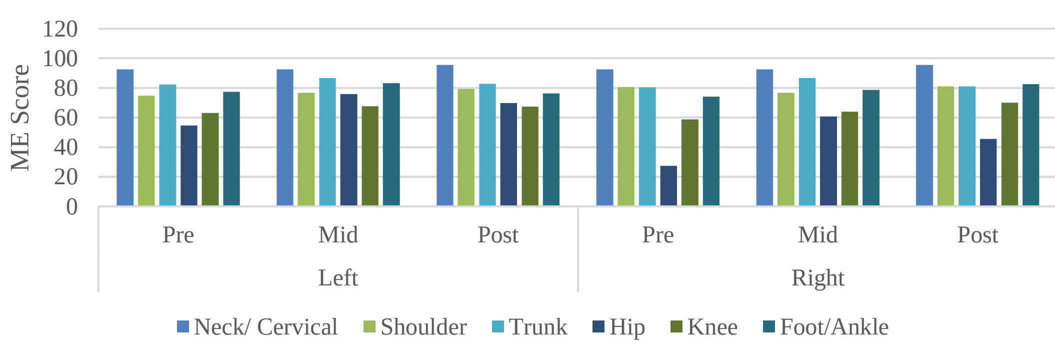

Figure 4.11. Overall Joint Symmetry Averages

Table 4.6.

Two-way ANOVA with Repeated Measures Results for Joint Symmetry

Joint	Source	SS	df	MS	*F*	*p*	Eta Sq
Neck/ Cervical Spine	Sides	0	1	0	-	-	-
	Tests	134.73	2	67.367	1	0.386	0.091
	Side * Test	0	1	0	-	-	-
Shoulder	Sides	168.51	1	168.51	4.131	0.07	0.292
	Tests	291.44	2	145.72	2.404	0.116	0.194
	Side * Test	97.76	2	48.88	0.314	0.734	0.030
Trunk/ Lumbar	Sides	109.99	1	109.99	0.416	0.534	0.040
	Tests	148.08	2	74.04	0.302	0.742	0.029
	Side * Test	12.392	2	6.196	0.972	0.395	0.089
Hip	Sides	8147.9	1	8147.9	7.86	0.019*	0.440
	Tests	872.73	2	436.36	1.440	0.260	0.126
	Side * Test	437.5	2	218.75	0.283	0.757	0.027
Knee	Sides	51.8	1	51.8	0.217	0.651	0.021
	Tests	682.7	2	341.35	3.06	0.069	0.235
	Side * Test	160.86	2	80.43	0.550	0.586	0.052
Foot/ Ankle	Sides	4.39	1	4.399	0.054	0.821	0.005
	Tests	315.03	2	157.52	0.708	0.504	0.066
	Side * Test	376.640	2	188.320	1.145	0.338	0.103

Neck/ Cervical Spine

For the neck/ cervical spine joint symmetry, there were identical scores on both sides, therefore no statistical significance found between the left and right sides. There was no statistical significance between the three tests (F = 1, P = 0.386, η_p^2 = 0.094). There was also no statistical significance found within the interaction of sides and tests. The scores for the left and right symmetry were identical for every test. There was no change between the pre and mid-test scores (pre 92.42 ± 8.71, mid 92.42 ± 8.71) and a slight increase from the mid to post-test (post 95.45 ± 7.79) but with no effect. A mean participant comparison for the neck/ cervical spine symmetry is shown in Figure 4.12.

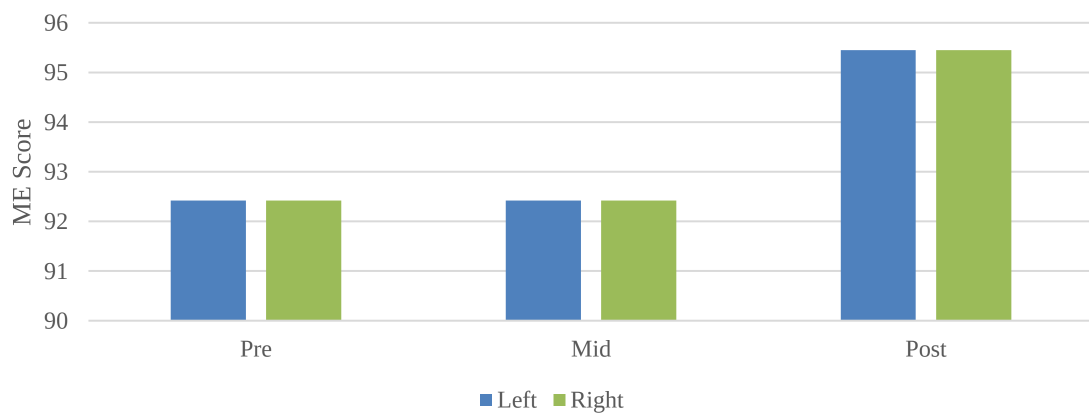

Figure 4.12. Left and Right Joint Symmetry Results for the Neck/Cervical.

Shoulder

For the shoulder joint symmetry, there was no statistical significance found between the left and right sides (F = 4.131, P = 0.07, η_p^2 = 0.292). There was also no statistically significant effect on tests (F = 2.404, P = 0.116, η_p^2 = 0.194). Finally, there was no statistical significance found within the interaction of sides and tests (F = 0.314, P

= 0.734, η_p^2 = 0.030). For the left side there was an increase from the pre to the mid-test (pre 77.99 ± 6.96, mid 79.87 ± 8.22) and a decrease to the post-test (post 75.77 ± 7.19) but with no effect. For the right side, there was a slight decrease from the pre to the mid-test and the mid to the post-test (pre 76.94 ± 7.14, mid 76.23 ± 8.27, post 70.89 ± 5.9). A mean participant comparison for the shoulder spine symmetry is shown in Figures 4.13.

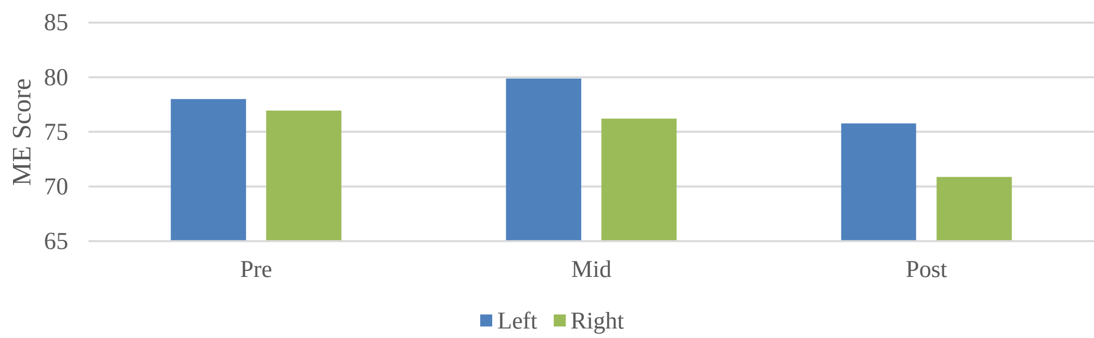

Figure 4.13. Left and Right Joint Symmetry Results for the Shoulder

Trunk/ Lumbar Spine

For the trunk/ lumbar spine symmetry, there was no statistical significance found between the left and right sides (F = 0.302, P = 0.742, η_p^2 = 0.029). There was also no statistical significance between the three tests (F = 0.416, P = 0.534, η_p^2 = 0.04). Finally, there was no statistically significant interaction between the sides and tests (F = 0.314, P = 0.734, η_p^2 = 0.03). On the left side, there was an increase from the pre to the mid-test and the mid to the post-test (pre 74.67 ± 12.92, mid 76.62 ± 79.22, post 79.22 ± 15.14), The right side decreased from the pre to the mid-test (pre 80.52 ± 15, mid 76.62 ± 17.8) and increased from the mid to the post-test (post 81.12 ± 18.96) but with no effect. A mean participant comparison for the trunk/lumbar spine symmetry is shown in Figure 4.14.

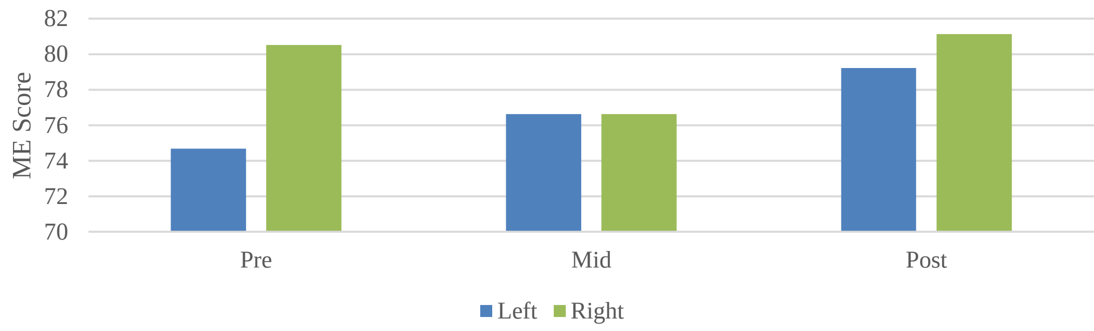

Figure 4.14. Left and Right Joint Symmetry Results for the Trunk/ Lumbar Spine

Hip

For hip joint symmetry, there was statistical significance between sides (F = 1.44, P = 0.260, η_p^2 = 0.126) and no significance between tests (F = 7.858, P = 0.019, η_p^2 = 0.440). There was also no statistical significance in the interaction between the sides and tests (F = 0.283, P = 0.757, η_p^2 = 0.027). On the left side there was an increase between the pre and the mid-test (pre 27.3 ± 29.13, mid 60.6 ± 35.96), then a decrease from the mid to the post-test (post 45.45 ± 37.33). The right side saw an increase from the pre to the mid-test (pre 27.28 ± 29.13, mid 60.6 ± 35.96) and a decrease from the mid to the post-test (post 45.45 ± 37.3). A mean participant comparison for the hip symmetry is shown in Figure 4.15.

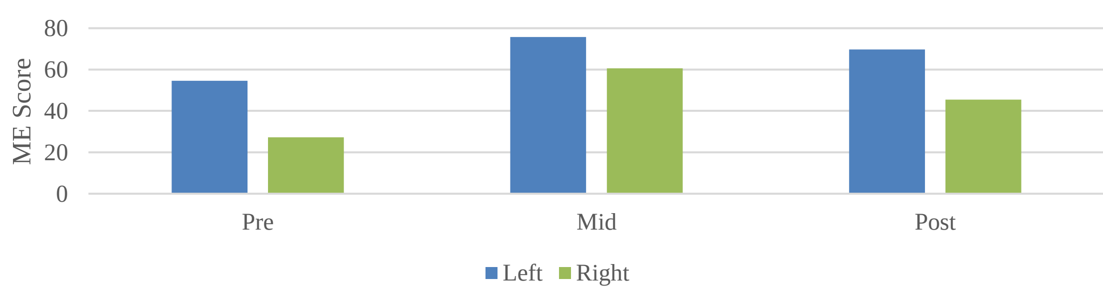

Figure 4.15. Left and Right Joint Symmetry Results for the Hip

Knee

For knee symmetry, there was no statistical significance found between the left and right sides (F = 0.217, *P* = 0.651, η_p^2 = 0.021). There was also no statistical significance between the three tests (F = 3.06, *P* = 0.069, η_p^2 = 0.235). Finally, there was no statistically significant interaction between the sides and tests (F = 0.550, *P* = 0.586, η_p^2 = 0.052). On the left side, there was an increase from the pre to the mid-test and the mid to the post-test (pre 58.86 ± 15.11, mid 64.03 ± 13.52, post 64.03 ± 13.52) but with no effect. The right side also increased from the pre to the mid-test (pre 58.86 ± 15.11, mid 64.03 ± 13.52) and the post-test (post 70.09 ± 15.69) but with no effect. A mean participant comparison for the trunk/lumbar spine symmetry is shown in Figure 4.16.

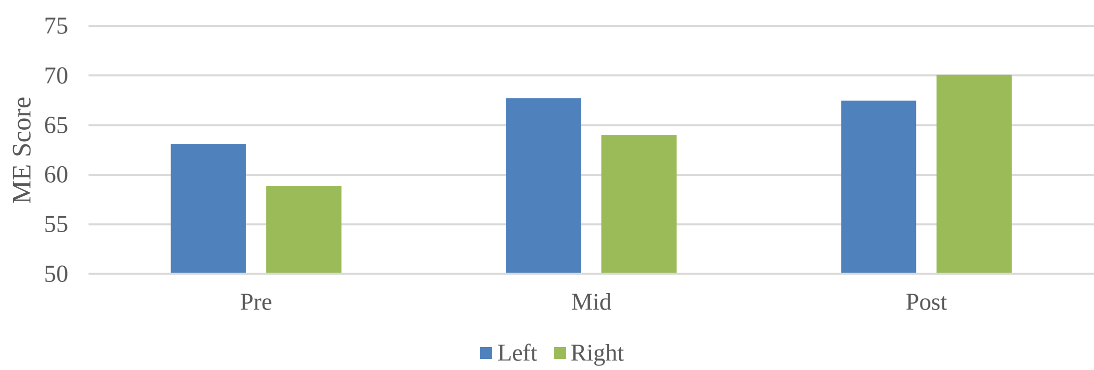

Figure 4.16. Left and Right Joint Symmetry Results for the Knee

Foot/Ankle

For foot/ ankle symmetry, there was no statistical significance found between the left and right sides (F = 0.054, *P* = 0.821, η_p^2 = 0.005). there was also no statistical significance between the three tests (F = 0.708, *P* = 0.504, η_p^2 = 0.066). Finally, there was no statistically significant interaction between the sides and tests (F = 1.145, *P* = 0.338, η_p^2 = 0.103). On the left side, there was an increase from the pre to the mid-test (pre 77.38 ± 12.15, mid 83.15 ± 13.64) and a decrease between the mid to the post-test (post 76.27 ± 15.81) but with no effect. The right side also increased from the pre to the mid-test (pre 74.06 ± 11.03, mid 78.71 ± 10.64) and the mid to the post-test (post 82.48 ± 15.61) but with no effect. A mean participant comparison for the trunk/lumbar spine symmetry is shown in Figure 4.17.

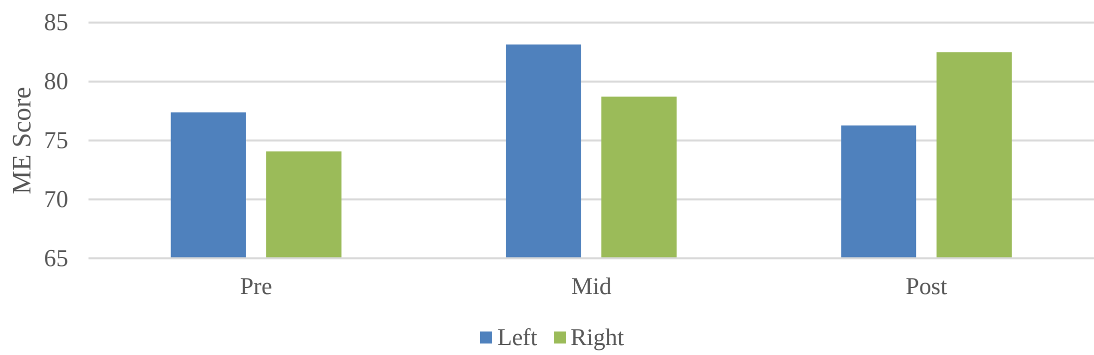

Figure 4.17. Left and Right Joint Symmetry Results for the Foot/ Ankle

CHAPTER FIVE

Discussion

Introduction

The purpose of this study was to determine if a Fusionetics movement efficiency test could be used to determine the effectiveness of lifetime fitness (LF) course activities in sedentary university students. Specifically, the goal was to determine how effective activities in FTP at Baylor University are at improving movement efficiency (ME). Statistical significance was found within the three tests of the overall ME scores, the tests of the overall symmetry, subgroups of the 2-leg squat and the 1 leg-squat, and between right and left symmetry of the hip joint.

Overall ME Scores

The main purpose of this study was to determine how effective FTP activities at Baylor University are at improving ME. Significance was found within the tests of the overall ME scores (see Table 4.2). The average ME score increased from the pre to the mid-test and decreased from the mid to the post-test. The pre and the mid-test scored were placed the good category and the post-test scores declined into the moderate category according to categorization specified by Fusionetics. Despite the participants representing sedentary college students, their results did not differ from athletic populations also averaging on the cusp of the good and moderate categories (Quick-Royal, 2020; Cornell & Ebersole, 2018). Between the pre and the mid-test, the average increased by an average of 1.59% ± 8.02 based on the amount and focus of activities in class while the post-test decreased by an average of -7.82% ± 7.85 from a greater percentage of endurance-based activities compared to strength-based.

One explanation for these results is the types of activities used in FTP (See Tables 3.3 and 3.4). In the first six weeks of the semester the students completed a Tabata workout, agility bootcamp, cardio relays, weight room basics (Hinge, Squat, and Bench Press), a running activity, kettlebell/ dumbbell workout, an obstacle course, another weight room, and 4 separate aerobic games (Table 3.3). These activities were between 30-45 minutes long and the students were involved two days a week either Monday and Wednesday or Tuesday and Thursday. The strength workouts included some of the same movements that the ME test uses such as squatting and push-ups. This increasing familiarity with the movements may have contributed to the increase in overall ME scores from the pre to the mid-test. On the other hand, the last six weeks of class did not contain as many of these types of workouts. The second half of the semester included a bootcamp workout (aerobic), weight room day, free cardio day (walk, run, bike, or elliptical), resistance bands workout, outdoor aerobic walking, power yoga, and again, four aerobic games (see Table 3.4). The aerobic activities did not include as much strength or similar movements as the first half of the semester. The strength workouts contained some of the same movements, but they were less common due to less class periods in the second half. The focus of the second half schedule was endurance based compared to the strength focus of the first half. Knowing this, the significance of the types of activities in physical activity courses is important to determine the ME in sedentary university students. Strength style activities improved ME scores at a greater rate than aerobic focused activities. Another interesting result is the degree to which the ME scores improved and worsened. There was a slight improvement in ME scores after six weeks of activity, two days a week. However, there was a greater decrement in ME scores with different activities despite same length of training. Physical activity was still occurring, but the type of the activity may determine the ME's rate of change. One purpose of intervention programs is to target and improve specific movement and muscular deficits (Cornell & Ebersole, 2018; Eckard et al., 2018). Fusionetics offers a two-part program including a ME test and intervention program. The program recommended by Fusionetics was not used in this study but may be effective for future research.

Regarding the overall ME symmetry, there were no statistically significant effects on side or interaction between test and side. There was a statistically significant effect on the tests. The overall ME symmetry scores increased from the pre to the mid-test and then decreased with the post-test. Overall right symmetry scores saw a slight decrease from the pre to the mid-test and a larger decrease from the mid to the post-test. In addition, for both right and left symmetry, the pre and mid-tests were categorized as good then the post-test declined into the moderate category. The types of activities could have contributed to this decline as there were more strength-based activities in the first half and more aerobically based activities in the second half.

The results of the overall ME scores and overall symmetry show that ME cannot be drastically improved in the span of a semester. Unfortunately, most universities only require a minimum of 1 credit hour of physical activity courses. One semester may not allow enough time with an instructor for students to improve ME. In addition, endurance-based activities were not proven effective in improving ME.

Subgroups

A secondary purpose of this study is to determine specific movement and muscular deficits of a sedentary university population. Each individual score was divided into the seven separate subgroups and then averaged across individuals for each test. Our findings indicate that there were a statistically significant effects on test in the 2-leg squat and the 1-leg squat (See Table 4.5). Regarding subgroup symmetry scores, statistically significance effects were found between sides for the hip joint.

Lower Body

The most common compensations for the 2-leg squat were feet flattening, lifted heels, excessive forward lean, and knee varus. Compensations such as flattening feet and lifting heels are signs of mobility issues. Flat feet occur when there are either tight muscles in the foot and calf or weak muscles surrounding the arch of the foot (Fahmy, 2022). The arch is used to absorb some of the loading demands. Optimal position is to have the heel, big toe, and outside of the foot in contact with the floor (Fahmy, 2022). For this to occur, mobility and strength must surround these areas to optimize the contact points. The results from these participants are logical because in a sedentary population there is limited mobility and strength. An interesting finding is that as the weeks progressed, the strength and mobility did not improve. Those participants who experienced this compensation in the pre-test, experienced similar compensations in the post-test. This trend shows that more endurance activities (see table 3.5) are not effective at increasing foot/ankle mobility.

The purpose of the 2-leg squat with heel lift is to emphasize the quadricep muscle group. A common compensation through all these tests was excessive forward leaning. This compensation suggests weak back extensors and hip extensors and may include tight gastrocnemius and soleus in combination with hip flexors (Fahmy, 2022). During the pre-test five participants experienced an excessive forward lean and by the post-test the participant number had reduced to three. This reduction could be from increased flexibility in both the calf muscles (gastrocnemius/ soleus) and hip flexors or may suggest increased back extensor strength. The activities in FTP support both theories through multiple strength workouts starting in the first half of the semester and then moving into multiple movement focused activities in the second half. There was only a small reduction in this category, so there could be more activities focused on back strength and leg flexibility to help accommodate for these commonly found compensations.

The single leg squat assessment had the most compensations out of the seven subgroups. The most common compensations were foot flattening, knee valgus, and loss of balance. Foot flattening as mentioned previously may suggest either tight muscles in the calf or unsupported arches. This result was also seen in the 2-leg squat. Knee Valgus is a common compensation usually suggesting weak abductors and gluteal muscles (Fahmy, 2022). Research has also shown that stronger core muscle activation can increase hip stability in a single leg squat (Shirley et al., 2011). This information is useful for this population because although not tested, low core stability is to be expected in a sedentary population. The weak core stability may also suggest overactive external rotators (Fahmy, 2022; Shirley et al., 2011). In addition, weak surrounding hip muscles and low core stability may have caused a loss of balance. Future research should include more in-depth reasoning behind a higher occurrence of knee varus in this population. Due to the setup of FTP activities and ACSM's recommendation of 2-3 days of strength training and 3-5 days of aerobic training per week (Riebe et al., 2018), there is not enough time in class for adaptations in this subgroup. Although increases in strength, endurance, and flexibility are a focus of the course (Ruckman, 2021), ME is not improving through the chosen activities. Activities need to teach and include more effective strength in the lower body, specifically gluteal muscles.

Explanations for symmetry differences are compensations used in these three lower body exercises. Paterno et al. (2007) mentions the assessment of lower body asymmetries are used to determine mechanical stability, isokinetic strength, and functional performance. The increased frequency of knee valgus during the lowering phase of the squats can be related to the landing phase of a jump. Cone and Lee (2021) state that greater knee instability was evident during frontal knee landings, causing a more forceful strain on the knee. The knee valgus in the lowering phase of the squat of this study shows knee instability and weak surrounding muscles causing this compensation. Another explanation could be the types of activities in FTP. The first half of the semester contained more bilateral power, speed, and agility activities whereas the second half was more sport-oriented utilizing unilateral movements. The muscular imbalances and weak core strength mentioned earlier, in addition to unilateral activities may have contributed to a difference between right and left symmetry in the hip joint.

Upper Body

The common compensation for the push-up test was low back arching and head moving forward. The reasoning behind the low back arching is the muscles in the lumbo-pelvic-hip-complex (LPHS) are imbalanced (Ambler-Wright, 2022). These muscles include the hip flexor complex, erector spinae, and latissimus dorsi. The muscle imbalance may cause limited range of motion in the LPHS and incorrectly stabilize the spine. The muscles that need to be strengthened to overcome this compensation are the anterior core, the gluteus maximus, and the hamstrings (Ambler-Wright, 2022). This will allow for the body to lift into the correct position. The head moving forward compensation is caused by overactive upper trapezius, levator scapulae, and sternocleidomastoid (Ambler-Wright, 2022). The underactive muscles are deep cervical flexors (Ambler-Wright, 2022). When the head moves forward there is a disconnection between the upper thoracic spine and the cervical spine, requiring a compensation to complete the full push-up (Ambler-Wright, 2022).

The shoulders movements consist of shoulder flexion, internal rotation, external rotation, and horizontal abduction. Of these four motions, horizontal abduction contained the most compensations. When comparing the separate tests, there was not a large increase in flexibility as expected. A study on sedentary females concluded that resistance training was not an effective mechanism for increasing shoulder flexibility (Santos et al., 2010). When looking at the FTP schedule, most of the activities were focused on aerobic capacity and lower body strength. Although flexibility was incorporated into warm-ups and cool-downs, time associated specifically to shoulder flexibility was not proven effective at increasing ME scores. For future recommendations, a consistent cooldown should be put in place for every workout including major muscle groups of both lower body and upper body, specifically shoulders.

Regarding upper body symmetry, there was no statistically significant effects on the tests, sides, or the interaction between tests and sides. One explanation is the lack of upper body strength and game activities. In the first half of the semester (see Table 3.3), a majority of the aerobic and strength activities were lower body dominant. In addition, three out of the four games included upper body. Activities in the second half of the semester (see Table 3.4) also contained limited upper body work. The left side contained higher symmetry scores throughout the tests than the right side. Right side symmetry could have been affected by the dominant use in games through throwing balls and frisbees. The left side symmetry may be higher due to a natural increase from activity, compared to a sedentary state. The overall pattern of decline of symmetry in both sides could be caused by the difference in number of activities using upper body between the first and second half of the semester .

Spine

Trunk and Lumbar Spine flexion and rotation had some of the highest scores from all the subgroups. In the pre-test, six out of eleven participants used a compensation for trunk rotation on both the right and left side of the body. This may suggest low flexibility in the thoracic and lumbar spine. These individual measures are not descriptive enough to indicate low back function (Schenk, 2004). There was improvement from the pre-test to the post-test which indicates that FTP activities are effective in increasing trunk rotation. This may be caused by including flexibility training before and after activities to increase range of motion in trunk rotation.

The cervical movement had no issues in the pre-test and remained constant through the post-test. There were no reported issues with cervical movement through the testing and through activities done in FTP.

Limitations

The first limitation of this study was the inequality between the first and second half activities. The class is structured around the number of rotations and limited amount of time in class. This semester, the rotations added up unevenly causing an unequal number of activities in the first and second half. This limitation may have been a cause in the declines in ME scores for the post-tests. Another limitation is the study exclusion criteria. The criteria limited students who had a previous injury in the past five years. Excluding this population may have reduced the data surrounding muscular and movement deficits and may have limited results in symmetry differences. Another limitation was variance in instruction. Although FTP is supervised by the same director and given the same activities, every section was taught by a different instructor. This variance in instruction between sections may have contributed to differences in results.

Future Research

Future research should include testing of sedentary students in university physical activity courses to determine if Fusionetics can detect ME problems. In addition, including testing over a longer period to determine what activities and duration will be more beneficial to improving ME. Future research should also focus on more consistent activity schedule, a wider inclusion criterion, and including a more specific intervention program to improve ME scores.

Conclusion

Physical activity courses in the university setting have importance in providing valuable information on health and fitness to the students. Physical activity courses may benefit from activities focused on movement and muscular deficits seen in students to improve ME. By improving ME, students will have more opportunities to enjoy lifelong fitness outside of the course and university.

APPENDIX

APPENDIX

Self-Injury Report

Participant Number:	**Section:**	**Date:**

Self-Injury Report

Please answer all questions regardless of whether you have experienced health problems in the past academic semester. Select the alternative that is most appropriate for you, and in the case that you are unsure, try to answer as best you can anyway.

A health problem is any condition that you consider to be a reduction in your normal state of full health, irrespective of its consequences on your sports participation or performance, or whether you have sought medical attention. This may include, but is not limited to, injury, illness, or pain.

Lower Body (Hips, Knee, Ankles, Feet, Toes)

1. Participation
   Have you had any difficulties participating in training and competition due to injury, illness, or other health problems during the past academic semester?
   a. Full participation without health problems
   b. Full participation, but with a health problem
   c. Reduced participation due to a health problem
   d. Could not participate due to a health problem
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________
2. Modified training
   To what extent have you modified your training or competition due to injury, illness, or other health problems during the past academic semester?
   a. No modification
   b. To a minor extent
   c. To a moderate extent
   d. To a major extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________

3. Performance
   To what extent has injury, illness or other health problems affected your performance during the past academic semester?
   a. No effect
   b. To a minor extent
   c. To a moderate extent
   d. To a major extent
   e. Health problem: ____
   f. Activity causing health problem (if applicable): __________________________
4. Symptoms
   To what extent have you experienced symptoms/health complaints during the past academic semester?
   a. No symptoms/ health complaints
   b. To a mild extent
   c. To a moderate extent
   d. To a severe extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________

Upper Body (Shoulders, Elbows, Wrists, Fingers)

1. Participation
   Have you had any difficulties participating in training and competition due to injury, illness, or other health problems during the past academic semester?
   a. Full participation without health problems
   b. Full participation, but with a health problem
   c. Reduced participation due to a health problem
   d. Could not participate due to a health problem
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________
2. Modified training
   To what extent have you modified your training or competition due to injury, illness, or other health problems during the past academic semester?
   a. No modification
   b. To a minor extent
   c. To a moderate extent
   d. To a major extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): _______________________
3. Performance
   To what extent has injury, illness or other health problems affected your performance during the past academic semester?
   a. No effect
   b. To a minor extent
   c. To a moderate extent
   d. To a major extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable):

4. Symptoms
   To what extent have you experienced symptoms/health complaints during the past academic semester?
   a. No symptoms/ health complaints
   b. To a mild extent
   c. To a moderate extent
   d. To a severe extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________

Trunk (High/ Low Back, Abdominals, Chest)

1. Participation
   Have you had any difficulties participating in training and competition due to injury, illness, or other health problems during the past academic semester?
   a. Full participation without health problems
   b. Full participation, but with a health problem
   c. Reduced participation due to a health problem
   d. Could not participate due to a health problem
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________

2. Modified training
   To what extent have you modified your training or competition due to injury, illness, or other health problems during the past academic semester?
   a. No modification
   b. To a minor extent
   c. To a moderate extent
   d. To a major extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________
3. Performance
   To what extent has injury, illness or other health problems affected your performance during the past academic semester?
   a. No effect
   b. To a minor extent
   c. To a moderate extent
   d. To a major extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________
4. Symptoms
   To what extent have you experienced symptoms/health complaints during the past academic semester?
   a. No symptoms/ health complaints
   b. To a mild extent
   c. To a moderate extent
   d. To a severe extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __

Cervical (Neck and Head)

1. Participation
   Have you had any difficulties participating in training and competition due to injury, illness, or other health problems during the past academic semester?
   a. Full participation without health problems
   b. Full participation, but with a health problem
   c. Reduced participation due to a health problem
   d. Could not participate due to a health problem
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________
2. Modified training
   To what extent have you modified your training or competition due to injury, illness or other health problems during the past academic semester?
   a. No modification
   b. To a minor extent
   c. To a moderate extent
   d. To a major extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________
3. Performance
   To what extent has injury, illness or other health problems affected your performance during the past academic semester?
   a. No effect
   b. To a minor extent
   c. To a moderate extent
   d. To a major extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________
4. Symptoms
   To what extent have you experienced symptoms/health complaints during the past academic semester?
   a. No symptoms/ health complaints
   b. To a mild extent
   c. To a moderate extent
   d. To a severe extent
   e. Health problem (if applicable): ____
   f. Activity causing health problem (if applicable): __________________________

Student’s Initials: ______________________

Completers Initials: __________________

Date: ______________________________

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