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COMPARATIVE CONTROLLED STUDY

Effect of Pilates and taiji quan training on self-efficacy, sleep quality, mood, and physical performance of college students

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Summary Methods of exercise such as Pilates and taiji quan, which have been shown to have beneficial effects on physical and mental characteristics, have been studied more often in samples of older participants. The purpose of this investigation was to examine the effects of a semester of either Pilates or taiji quan training on perceived self-efficacy, sleep quality and mood, as well as strength and balance in college-age individuals. Self-efficacy was found to be improved in the Pilates and taiji quan groups and there was a trend towards improvement in sleep quality. Mood was found to be improved significantly in the Pilates group while the taiji group showed a trend towards improvement. There were no changes or group differences in the strength or balance measures. Pilates and taiji quan are effective exercise modes to improve mental parameters in college-age individuals.

Introduction

In developing his method, Joseph Pilates "combined the mental focus of and specific breathing of yoga with the physicality of gymnastics and other sports" (Ungaro, 2002, p. 8) for the ideal of attaining a complete coordination of body, mind, and spirit (Gallagher and Kryzanowska, 2000). The mind–body approach is further elucidated by the principles (CCCPFB) that Pilates founded his method on: *centering*, *concentration*, *control*, *precision*, *flow*, *and breath* (Adamany and Loigerot, 2004; Adams and Quin, 2007; Gallagher and Kryzanowska, 1999; Siler, 2000; Ungaro, 2004).

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Anecdotal evidence suggests that as the Pilates method increases core strength, the natural flexibility of the spine and limbs returns. However, there has been little research on the effectiveness of Pilates exercise and any studies found have been poorly controlled (Herrington and Davies, 2005). A recent review of literature identified only three published clinical trials investigating the effectiveness of Pilates training in healthy adults (Bernardo, 2007).

Another mind–body method is taiji quan (also transliterated as tai chi chuan), an ancient Chinese martial art characterized by slow circular movements, breath regulation, and concentration or mindfulness. It is a low-impact, moderate-intensity aerobic exercise (Lan et al., 2004). Most studies of the effect of taiji quan practice have focused on middle-aged to older adults and have documented improvements in health parameters such as immune function, balance, and strength.

Perceived self-efficacy is related to maintenance, effort, and performance of various specific behaviors, including health-promotion activities (Bandura, 1997; Noble and Robertson, 1996). Perceived self-efficacy is one's judgment of his/her ability to perform a specific activity. This judgment is based on four sources of information: (1) mastery experiences that serve as indicators of capability; (2) vicarious experiences [observations of others] that alter efficacy beliefs through transmission of competencies and comparison with the attainments of others [if she can do it, I can do it]; (3) verbal persuasion and social influences that one possesses certain capabilities [you can dance very well]; and (4) physiological and affective states from which people partly judge their capableness, strength, and vulnerability to dysfunction [my stomach is in knots, I feel exhausted] (Bandura, 1997).

Research reviewed by Bandura (1997) across a wide variety of activities shows that, controlling for ability, one's reported perceived self-efficacy regarding a specific task remains a significant contributor to performance accomplishment. Using pre- and post-exercise program self-efficacy and physical fitness measures, McAuley et al. (1991) investigated the influence of both short- and long-term exercise programs on physical activity self-efficacy, adherence to exercise self-efficacy and physiological function of middle-aged, previously inactive adults. Both short- and long-term groups showed significant gains in physical activity and adherence self-efficacy as well as significant gains in physiological functioning.

An additional important health indicator is sleep quality. Epidemiologic studies have consistently shown an association between self-reports of exercise and better sleep, and exercise is often recommended as an important sleep aid (Hublin et al., 2001). However, experimental studies demonstrate that there is no single effect of exercise on sleep (O'Connor and Youngstedt, 1995; Youngstedt et al., 2003). King et al. (1997) found a regular moderate-intensity exercise program to be effective in improving sleep complaints of older adults, and Li et al. (2004) found improved sleep quality in older practitioners of taiji quan.

In addition to the effects of exercise on self-efficacy and sleep quality, the differential effects of various types of moderate physical exercise on mood enhancement are still a question of interest. A number of studies have shown that changes in mood and anxiety through physical exercise may be related to the form of the exercise (Berger and Owen, 1988, 1992; Jin, 1989, 1992). Taiji quan practice, with its emphasis on physical and mental training, has been found to have a positive impact on mood in a number of these studies, but most of these are focused on middle-aged to older adults.

The few studies that include college-aged students (aged 18–30) have generally found positive effects of taiji quan on the self-assessed physical and mental health of college students. Jin's (1989) study of 33 beginning (average age: 33.2 ± 9 years) and 33 experienced (average age: 37.7 ± 14.3 years) taiji quan practitioners found that the practice of taiji quan raised heart rate, increased noradrenaline excretion in urine, and decreased salivary cortisol concentration at levels comparable to those found with moderate exercise. The subjects also reported improvements in mood and fatigue. A second study by Jin (1992) focused on the efficacy of taiji, brisk walking, meditation, and reading in reducing mental and emotional stress ($n = 96$). Mood states were improved and salivary cortisol levels dropped significantly for all treatments. However, the adrenaline level after taiji quan exercise dropped more in comparison with that after meditation, and the noradrenaline level was higher after taiji quan than after reading. Taiji participants also reported greater reduction of state anxiety and enhancement of vigor as compared to the reading control group, but this discrepancy disappeared when expectancy regarding the outcome of treatments was used as a covariate. Szabo et al. (1998) compared aerobic dance, weight training, martial arts, taiji quan, yoga and music appreciation and found the combined taiji and yoga group reported higher levels of tranquility than all other exercise groups. This group also reported lower psychological distress, fatigue, and exhaustion than participants in the

martial arts group. Wang et al. (2004) reported on a 3-month intervention of taiji quan in 30 college students (mean age: 24.23 ± 2.74 years). Using a pre- and post-test design comparing scores on the multidimensional SF-36v2 health survey questionnaire, general health and bodily pain were significantly improved as were the mental health measures of vitality, role function, and perceptions of mental health.

Balance plays a critical role in any activity. Static balance involves minimizing postural sway in a motionless stance, i.e., sitting or standing while dynamic balance involves the ability to maintain control of the center of gravity while moving it over the base of support, i.e., walking, climbing stairs, and getting up from a chair. A variety of exercises have been shown to have a positive effect on balance especially in older adults. Johnson et al. (2007) found a significant change in dynamic balance in healthy adults after completing 10 Pilates-based exercise sessions, and Kaesler et al. (2007) found improvement in some components of static and dynamic postural sway in their sample of older adults. Similar improvements in balance in older adults have been found in studies of taiji quan (Busing, 2005; Yuhua et al., 2007).

Therefore, the purpose of this study was to better understand the effect of Pilates and taiji quan training in healthy young adults on perceived self-efficacy, sleep quality, mood, strength, and balance. Studies of other modes of exercise have included these variables, but at this point no studies have documented effects of Pilates or taiji participation on these variables in the college-age population.

Methods

Study design

Study participants were recruited from five physical education classes (three Pilates mat classes and two taiji quan classes), and two recreation classes (an outdoor leadership class and a special recreation class) served as a control group. Subjects were students at a moderately sized state university in the fall and spring semesters of one academic year. The Pilates classes met twice a week for 75 min each class period or three times per week for 50 min each class period for a 15-week semester. The instructors was comprehensively trained and certified in the Pilates method. The Chen style taiji quan classes met twice a week for 50 min each session for 15 weeks and followed principles outlined by Yang (2005). Participants in the recreation classes were actively involved in their own preferred forms of exercise outside of class, but the class content was theoretical. During the first week of class, at mid-term and at the end of the semester, students were asked to complete in class a survey instrument containing self-regulatory efficacy scales, sleep quality indexes, mood scales, and demographic questions. At the beginning and end of the semester, students in five of the classes (three Pilates, one taiji quan, and one special recreation) were assessed for balance and strength.

Procedures

Self-efficacy

A four-item self-regulatory efficacy instrument (Harrison and McGuire, 2008) was used as well as a self-efficacy measurement specific to either Pilates or taiji quan because self-efficacy measures must be specific to the activity being measured (Bandura, 1997). Since no measurement tools of Pilates self-efficacy (PSE) were found, a 14-item, seven-point Likert-type scale on widely accepted principles of the Pilates method was developed (Table 1). Other experienced Pilates practitioners reviewed the instrument to establish face validity of the scale, and initial testing resulted in high inter-item reliability (Cronbach's alpha = .935). Scores on the PSE scale potentially ranged from 14 to 98 with higher scores indicating greater self-efficacy. A 12-item Taiji Quan Self-Regulatory Efficacy Scale (TSE) was also developed and reviewed by experienced practitioners. Initial testing resulted in high inter-item reliability (Cronbach's alpha = .897). Scores potentially ranged from 12 to 84 with higher scores indicating greater self-efficacy.

Sleep quality

The Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) was chosen for this investigation and consists of 19 self-rated questions related to normal sleep habits. The possible range of scores is 0–21 points with lower scores indicating better sleep quality. The Pilates group completed the PSQI at beginning and end of the semester, but the other groups completed an abbreviated form addressing only daytime dysfunction and subjective sleep quality. A PSQI global score >5 has served as a marker to distinguish sleep disturbances in insomnia patients versus controls (Backhaus et al., 2002).

Table 1 Items from Pilates self-efficacy (PSE) instrument based on six principles of Pilates.

Principle	Item from PSE
Centering—the ability to focus attention on one small sensation.	I can move from my core strength. I can maintain correct posture.
Concentration—ability to focus one's attention as the mind wills the body into action, or the mind/body connection.	I can feel the articulation of my spinal column. I can visualize myself doing the exercises correctly. I can sense how I am doing the exercises by using an internal focus. I can modify the exercises as needed.
Control—promotes injury prevention and is empowering, mindfulness helps to produce coordinated results.	I can coordinate smooth movements of my arms and legs. I can move with a sense of control in movement. I can lower myself to the floor with control.
Precision—the ability to avoid sloppy, mindless movements, increases the likelihood of producing the desired results.	I can move with a sense of precision in movement. I can release unnecessary muscle tension.
Flow—transitional ability, the ease from which one moves from one experience or exercise to the next.	I can smoothly transition from one movement to another.
Breath—awareness and control of the breath can lead to increased lung capacity, efficiency, coordination of physical functioning and optimal muscular patterning in everyday tasks.	I can focus completely on coordinating my breath with body movements. I am aware of using my breath efficiently.

Mood

The Four Dimensional Mood Scale (Huelsman et al., 1998) was utilized in this investigation and is a 20-item adjective checklist using a five-point Likert format (1 = not at all, 5 = extremely). Scores on the four scales are the mean response to the items on the scale: positive energy (six items), tiredness (seven items), negative arousal (seven items), and relaxation (nine items). There is evidence for generally good internal consistency of the scales as well as concurrent and discriminant validity (Huelsman et al., 2003).

Strength and balance

A subset of participants ($n = 67$) were assessed for lower body back and leg strength through the use of a back and leg dynamometer. Subjects were asked to exert three maximal effort isometric pulls while standing on the dynamometer platform. The strength reading was obtained from the dynamometer dial and the highest reading used for analysis.

This smaller group of participants was also assessed for balance ability when standing on a force platform on the dominant leg with the eyes closed. Postural sway was measured during this postural control test. The test was conducted on a specialized balance platform with a computer and software package (AMTI Balance Clinic, Boston, MA, USA) used to record and analyze the results.

Results

Demographics

Statistical analyses were conducted using the Statistical Packages for Social Sciences (SPSS), version 14 (SPSS Inc., Chicago, IL, USA). A total of 127 students participated in the study (Pilates $n = 51$, taiji quan $n = 35$, special recreation $n = 41$), but data was available at all three points in time for only 98 participants (Pilates $n = 41$, taiji quan $n = 29$, special recreation $n = 28$). A Chi-square on possible differences in gender and independent t-tests on possible differences in age, and hours of weekly exercise were non-significant when the complete data group was compared with the group eliminated from the study. Participants included in the study ranged in age from 18 to 32 years of age (mean = 21.27, S.D. = 2.24). Groups differed significantly by gender distribution: Pilates = 37 female and 4 male; taiji quan = 4 female and 25 male; special recreation = 9 female and 19 male. An additional initial difference between the groups was that the special recreation group reported significantly higher levels of weekly exercise (mean = 10.50, S.D. = 6.72) compared to the Pilates (mean = 5.03, S.D. = 2.89) and taiji quan groups (mean = 6.03, S.D. = 3.90). The following comparisons in the groups across time were calculated using linear mixed model statistical analyses using a Toeplitz residual covariance structure. Mixed model analyses provide a framework for analyzing data with dependent observations

using an iterative process of calculating a residual covariance structure. This results in estimates of the degrees of freedom for the *F*-statistics.

Measurements

Self-efficacy

Self-efficacy specific to Pilates as measured by the PSE increased significantly over the course of the semester from an initial mean of 64.6 to a final mean of 88.9 (paired *t*-test, $t(40) = -13.05$, $p = .0005$). Self-efficacy specific to taiji quan as measured by the TSE also increased over the course of the semester from an initial mean of 57.6 to a final mean of 63.2 ($t(28) = -4.504$, $p = .0005$). Participants perceived themselves as being more able to control their movements mindfully at the end of the semester than at the beginning. Initial PSE scores and initial self-regulatory efficacy scores were significantly correlated ($r(39) = .36$, $p = .02$), and TSE scores and initial self-regulatory efficacy scores correlated at a similar level ($r(27) = .32$, $p = .09$).

A mixed model analysis of self-regulatory efficacy scores found a significant group effect ($F(2, 99.95) = 5.135$, $p = .008$), time effect ($F(2, 117.02) = 3.201$, $p = .044$), and group by time interaction ($F(4, 116.92) = 3.212$, $p = .015$). The Pilates group rated their self-regulatory efficacy higher than the special recreation group at the beginning of the semester, and the Pilates group scores were significantly higher at the end of the semester than at the beginning of the class (Figure 1). Self-regulatory efficacy scores for the other two groups were essentially unchanged from the beginning to the end of the semester.

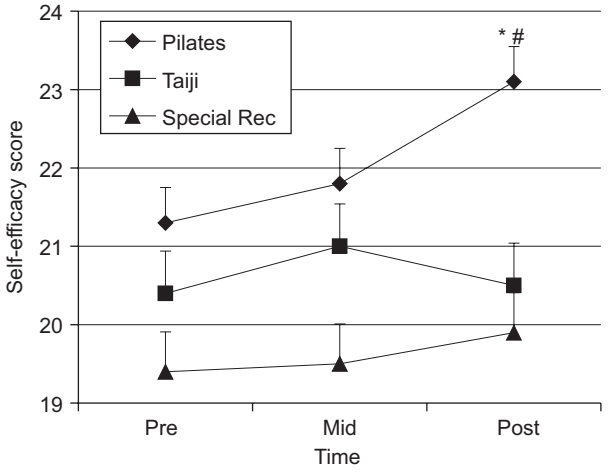

Figure 1 Self-efficacy scores. Values expressed as mean ± S.E.: ∗, significant difference from pre-test value; ♯, significant difference from special recreation value.

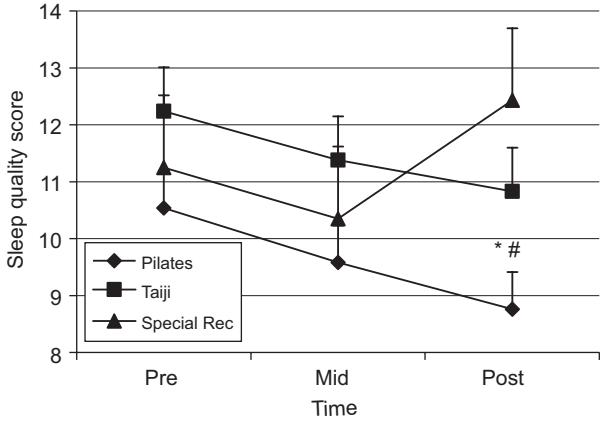

Figure 2 Sleep quality scores. Values expressed as mean ± S.E.: ∗, significant difference from pre-test value; #, significant difference from special recreation value.

Sleep quality

In the Pilates group sleep quality as measured by the PSQI showed some improvement from beginning ($n = 40$, mean = 6.22, S.D. = 3.12) to end of the semester (mean = 5.37, S.D. = 3.58) ($t(39) = 1.891$, $p = .066$). Pilates participants were sorted using the PSQI scores into groups that scored the same as insomniacs (PSQI > 5) and normal sleepers. At the beginning of the semester 52.5% of the Pilates participants ($n = 21$) scored in the same range as insomniacs, but that number had reduced significantly by the end of the semester to 35% ($n = 14$) of the Pilates participants ($\chi^2(1, n = 40) = 9.528$, $p = .002$).

Using the abbreviated sleep quality scale (three items, Cronbach's alpha = .757), a mixed model analysis of the Pilates classes, taiji quan classes and only one special recreation class ($n = 81$) found no statistically significant differences although the group effect barely missed significance ($F(2, 78.61) = 2.749$, $p = .07$) (Figure 2). One special recreation class was dropped from this analysis because data was not available for the three-item sleep quality items at the end of the semester. The Pilates and taiji quan groups demonstrated a trend towards improved sleep quality over the course of the semester while the special recreation class demonstrated improved sleep mid-semester and an end of semester worsening of sleep quality.

Mood

A mixed model analysis of positive mood scores (positive energy) found significant differences

across time ($F(2, 129.58) = 5.155$, $p = .007$) and group by time ($F(4, 129.59) = 2.463$, $p = .048$). Initially, the special recreation group positive mood scores were higher than the Pilates group, but by the end of the semester, the Pilates positive mood scores had increased to the same level as the special recreation group, which remained essentially the same as the beginning of the semester. The taiji quan group scores trended upward from the beginning to the end of the semester but not as much as the Pilates group (Figure 3).

A mixed model analysis of tired mood scores found no significant differences across group or time, and the group by time interaction barely missed statistical significance ($F(4, 135.86) = 2.345$, $p = .058$). Using a similar analysis of relaxed mood scores, significant group ($F(2, 95.09) = 6.442$, $p = .002$) and time ($F(2, 129.60) = 6.814$, $p = .002$) effects were found. Using estimated marginal means, the taiji group reported significantly higher relaxation scores than the Pilates group, and the Pilates scores at the end of the semester were significantly higher than at the beginning (Figure 4).

A mixed model analysis of negative mood scores found a significant group by time interaction ($F(4, 136.54) = 3.840$, $p = .005$). The Pilates and taiji groups experienced a decrease in negative mood mid-semester and returned to beginning semester levels by the end of the semester, while the special recreation group experienced a spike in negative mood scores which reduced by the end of the semester to levels similar to their scores at the beginning of the semester (Figure 5). In other words, the difference in groups occurred mid-semester, and the negative mood scores were similar at the end of the semester by group as they had been at the beginning of the semester.

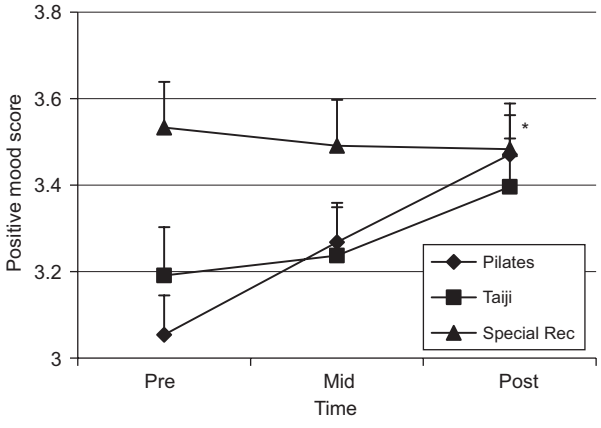

Figure 3 Positive mood scores. Values expressed as mean ± S.E.: ∗, significant difference from pre-test value (Pilates group only).

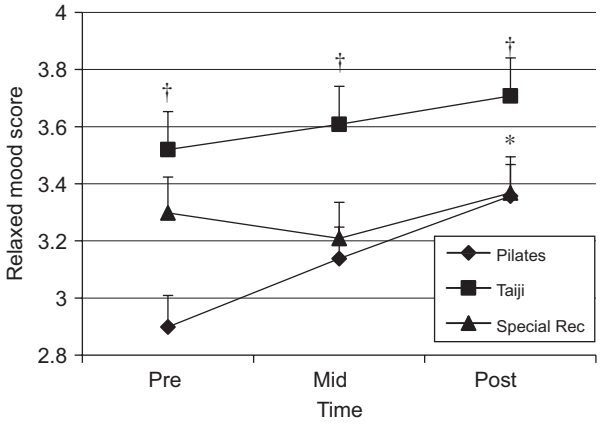

Figure 4 Relaxed mood scores. Values expressed as mean ± S.E.: ∗, significant difference from pre- and mid-test values (Pilates group only); †, significant difference from Pilates value.

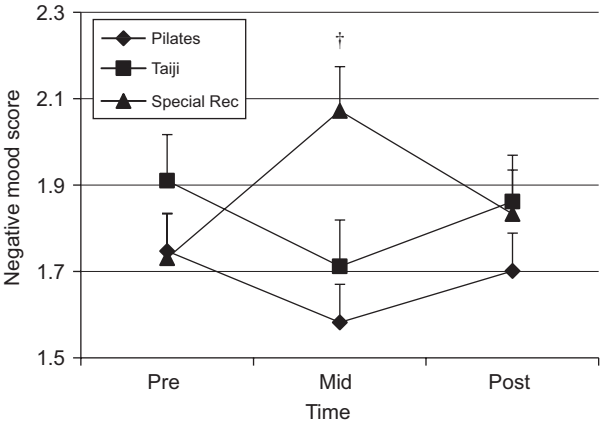

Figure 5 Negative mood scores. Valued expressed as mean ± S.E.: †, significant difference between Pilates and special recreation group.

Strength and balance

Initial dynamometer measures were correlated to the age of participants ($r = .24$) and the number of hours participants reported exercising weekly at the beginning of the semester ($r = .41$). Strength varies by gender, so gender was used as a factor in a mixed model analysis of the 67 individuals for whom strength measures were available at both the beginning and end of the semester. An effect was found only for gender ($F(1, 61) = 59.773$, $p = .001$). When the effects of gender were considered, there were no differences between the groups from the beginning to the end of the semester in terms of leg and back strength as measured by the dynamometer. Regarding balance, a mixed model analysis using the 61 individuals for whom beginning and end of semester measures were available yielded no group or time effect.

Discussion

Overall, the results of this investigation were similar to other studies performed in older populations and/or with similar exercise modes (Pilates, taiji). Study results indicate that students who participated in Pilates classes experienced significant improvements in self-efficacy and positive mood, with trends towards improved sleep quality and a reduction in negative mood over the course of a semester. The taiji group primarily showed trends of improvement. As expected from previous studies, there were complex interactions between the health variables, type of exercise and time of semester.

Measurements

Self-efficacy

Research across a wide variety of activities shows that, controlling for ability, self-efficacy regarding a specific task remains a significant contributor to performance accomplishment (Bandura, 1997). Our findings regarding Pilates support those of McAuley et al. (1991), as we found an increase in self-regulatory self-efficacy with exercise programs of varying duration. Interestingly, the taiji group did not show the same level of increase in self-regulatory efficacy, although there was an increase in self-efficacy specific to taiji movements. Li et al. (2001) also found increases in self-efficacy specific to taiji movement in participants of a 6-month taiji program for elderly participants

Sleep

Rates of poor quality of sleep in college students have varied from study to study depending on sample and measures of sleep quality used. For example, 44% of first-year college students in a study in Taiwan reported sleep problems (Yang et al., 2003). Rates of poor sleep quality in medical college students have ranged from 38% to 19% (Feng et al., 2005; Medeiros et al., 2001). Some studies have found that sleep quality improves over the course of semester (Hawkins and Shaw, 1992; Pilcher and Ott, 1998) while other studies found the opposite (Brown et al., 2006). The results of this investigation are in agreement with those showing nearly half of college students exhibit some problems with sleep quality. This investigation also supports the concept of exercise somewhat improving sleep quality overall in young adults, although the results of this investigation were not as dramatic as in studies with older individuals (King et al., 1997; Li et al., 2004).

Mood

Many systems of the body interact in a holistic manner together with positive and negative moods. Thayer's (1989) biopsychological mood theory anticipates that activities such as exercise or techniques involving control of thoughts would be integrally related to mood improvement. Indeed, the subjects in four studies reported by Thayer et al. (1994) identified exercise as the most effective mood-regulating behavior. The greatest improvement in positive mood was seen in the Pilates group. However, the participants in this study had no change in negative or tired mood from the beginning to the end of the study. The Pilates and taiji quan groups did show improvement in negative mood at the mid-term timepoint while the control group showed a worsening of negative mood the same time.

Strength and balance

Strength and balance measures were unaffected by Pilates and taiji training in this age group. There are likely several reasons for these findings. College-age individuals are at a peak regarding strength and balance and highly focused training on these variables is necessary to elicit any measurable change. In older individuals, where the largest gains are often seen, the exerciser is already at a physical deficit and the exercise can result in significant improvements. Although both Pilates and taiji have strength and balance as components, the training is not as likely to elicit a measurable change in this age group.

Conclusions

The results of this study indicate that students who participated in Pilates classes experienced the largest improvements in self-regulatory self-efficacy, positive mood, and sleep quality over the course of a semester. The lack of improvement in strength and balance measures may be due to the methods used for measuring these characteristics. Our results must be interpreted with caution because of the lack of random assignment to groups and the uneven gender representation in the groups.

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