EXERCISE SCIENCE

Effects of a Weight Training Personalized System of Instruction Course on Fitness Levels and Knowledge

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Abstract

Effective instruction in a university physical activity program is essential if the program desires to meet the National Association for Sport and Physical Education (NASPE, 1998) guidelines for an appropriate college/university physical activity instructional program. To meet these guidelines, an instructor can use the Personalized System of Instruction (PSI) model. The purpose of this study was to measure the effectiveness of using the PSI model in a university physical activity weight training course. Participants (n = 22) enrolled in a beginner weight training course were administered the FITNESSGRAM fitness test and a 50-question knowledge test before and after the 15-week PSI weight training course. Paired-samples t tests with Bonferroni correction revealed no significant difference in the Progressive Aerobic Cardiovascular Endurance Run (PACER) test, back saver sit and reach test, and trunk lift test, but did reveal a significant difference for curl-up test, $t(21) = -4.335$, $p < .007$; push-up test, $t(21) = -5.080$, $p < .007$; percentage body fat, $t(21) = 5.722$, $p < .007$; and knowledge test, $t(21) = -7.247$, $p < .007$. If a goal of the beginning weight training physical activity

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course was to promote student learning, the PSI weight training course was effective.

According to the National Center for Health Statistics (2004), physical activity in America decreases with age. The proportion of college-aged adults participating in regular, leisure-time activity dropped to 36.6% (Centers for Disease Control and Prevention [CDC], 2006), while obesity rates have tripled in young adults aged 18 to 29 in the past three decades from 8% in 1971–1974 to 24% in 2005–2006 (CDC, 2009). Studies investigating college students have reported the average weight gain is 1 to 6 pounds during the first semester (Anderson, Shapiro, & Lundgren, 2003; Hoffman, Policastro, Quick, & Lee, 2006; Huang et al., 2004; Jung, Bray, & Ginis, 2008; Levitsky, Garay, Nausbaum, Neighbors, & Dellavalle, 2006). Gruber (2008) states one possible reason for the weight gain is a decrease in physical activity levels. One possible solution to overcome these compounding obstacles is for universities/colleges to offer effective physical activity instructional programs. Such programs are a vital component in the education of college-aged adults (National Association for Sport and Physical Education [NASPE], 2007). The NASPE (1998) stated an appropriate and quality college/university physical activity (PA) instructional program is one that "(1) has education as its central mission, (2) a health-related physical activity/skill acquisition emphasis, (3) offers a variety of physical activity courses to reflect individual interests, (4) echoes societal needs, and (5) promotes safe and lifelong participation in health-enhancing physical activity" (p. 3).

Effective teaching practices include high amounts of Academic Learning Time (ALT), high success rates, high quality of practice, low management time, and high rates of individualized feedback (Rink, 2006). These practices included in a PA program will ensure that the university/college is meeting the NASPE guidelines and recommendations. Choosing an appropriate instructional model for the PA program may promote physical activity and the consistent implementation of effective teaching practices. An instructional model is a plan that can be used to design curriculums, create instructional materials, and guide instruction (Joyce, Weil, & Calhoun, 2004). Metzler (2005) described several instructional models used in a

physical education setting. One specific instructional model is the Personalized System of Instruction (PSI) model. The PSI model was first designed by Fred Keller (1968), which is known as the "Keller Plan." Burton, Moore, and Magliaro (1996) described PSI as an interlocking system of instruction, which consists of sequentially progressive tasks. Keller identified five essential features of a personalized course: (a) go-at-your-own pace; (b) unit perfection requirement; (c) use of lectures and demonstrations as vehicles of motivation; (d) related stress upon the written word in teacher–student communication; and (e) use of proctors to allow repeated testing, immediate scoring, tutoring, and a marked enhancement of the personal-social aspect of the educational process.

The PSI model was specifically designed for psychology courses, but Siedentop (1973) was the first physical educator to suggest that the model could be utilized in a physical education setting. Metzler (2005) described how to apply the PSI model in a physical education setting by utilizing the following characteristics: (a) content selection, (b) managerial control, (c) task presentations, (d) engagement patterns, (e) instructional interaction, (f) pacing, and (g) task progression. For a further description of these characteristics, see Metzler (2005). The PSI is unique in that all content is produced in a workbook that students use instead of the teacher providing direct instruction. Metzler (2005) stated the workbook must have attendance policies, class rules and disciplinary plan, dressing out policies, a process for getting and returning equipment, a grading policy and applicable policies, procedures for starting each class, a complete content list and all PSI learning tasks, all required readings (rules, strategies, history, etc.), and a student progress chart for completed tasks.

Research using the PSI model in physical education reported higher rates of student content engagement, skill practice time, ALT, and student success at learning tasks compared to Direct Instruction (Metzler, 1984). The PSI model in physical education had significantly higher learning gains for students compared to Direct Instruction (Cregger, 1994; Metzler, 1986). Metzler, Eddleman, Treanor, and Cregger (1989) discovered that teachers who used the PSI model spent less than 1% of class time managing the learning environment and performing task presentations while also providing three times the verbal and nonverbal feedback compared to non-PSI teachers. Research on the PSI in physical education settings has shown the positives of using the model, but research has not

been conducted on its effectiveness in a fitness-oriented physical education course. The purpose of this research was to measure the effectiveness of using the PSI model in a university physical activity weight training course.

Method

Participants and Setting

The setting of this investigation was a beginning university weight training course offered at a university PA program located in the southeastern United States. The course met twice per week for 50 minutes each meeting. Participants were 22 university students (17 males and 5 females) with an age range of 18 to 48 (M = 20.77, SD = 6.24) enrolled in the 15-week weight training course. Participation was voluntary, and no extra credit was provided. The Institutional Review Board for the Protection of Human Subjects approved the investigation prior to data collection.

The weight training course instructor was a graduate assistant who had previous experience teaching weight training. The instructor held a Health and Physical Education teaching certificate and was trained to use the PSI model. Metzler (2005) stated teachers using the PSI need expertise in the areas of (a) designing developmentally appropriate activities, (b) writing appropriate learning objectives, (c) analyzing tasks and designing an appropriate progression of the content, and (d) writing performance assessments into the task structure. Training entailed course work in the undergraduate and graduate level curriculum courses and focused on the development of the necessary expertise to fully implement the model. Before the course began, one researcher met with the instructor and discussed how the PSI would be implemented in the course. The primary researcher and instructor designed the PSI weight training workbook and then thoroughly discussed the instructional process. Metzler (2005) described teacher and student benchmarks that verify the PSI model was planned and implemented correctly. The primary researcher discussed these benchmarks (Metzler, 2005) with the instructor to ensure the model would be followed during the intervention.

Instrumentation

FITNESSGRAM. Aerobic capacity, muscular strength/endurance, flexibility, and body composition were measured via the FITNESSGRAM. The components included the Progressive

Aerobic Cardiovascular Endurance Run (PACER) test, curl-up test, push-up test, back saver sit and reach test, and trunk lift test. Body composition was measured using three skinfold sites with Lange Skinfold Calipers (Beta Technology, Santa Cruz, CA) based on gender (i.e., males = chest, abdomen, thigh; females = triceps, suprailiac, thigh). The sum of skinfolds was used to calculate density of body using formulas in Table 1. Percentage body fat was calculated by inserting density of body calculations in percentage body fat equations based on age, gender, and race (see Table 2). All body composition measures were taken by an experienced test administrator, who was previously trained as a Health Fitness Instructor from the American College of Sports Medicine. The test administrator measured skinfolds three times at each site, and each skinfold measurement site had to be within 1 millimeter to ensure reliability.

Knowledge test. The 50-question weight training knowledge test (McGee & Farrow, 1987) assessed overall weight training knowledge. Questions focused on the types of exercises used in weight training, lifting techniques, and anatomy of muscles being worked, which best reflected the objectives of the unit. The knowledge test had no data quality coefficients, but other researchers have used the test bank (French, Werner, Rink, Taylor,

Table 1

Equations for Density of Body

Gender	Skinfold Sites	Age	Density of Body Equations
Male	∑3SKF = (Chest + Abdomen + Thigh)	18–61 years	Db = 1.109380 - 0.0008267 (∑3SKF) + 0.0000016 $(\sum 3SKF)^2$ - 0.0002574 (Age)
Female	∑3SKF = (Triceps + Suprailiac + Thigh)	18–55 years	Db = 1.0994921 - 0.0009929 (∑3SKF) + 0.0000023 $(\sum 3SKF)^2$ - 0.0001392 (Age)

Note. Db = Density of Body

Source. Jackson and Pollock (1985)

Table 2

Equations for Percentage Body Fat

Population	Age	Percentage Body Fat Equations
White Male	17–19 years	(4.99 / Db) – 4.55
	20–80 years	(4.95 / Db) – 4.50
Black Male	18–32 years	(4.37 / Db) – 3.93
White Female	17–19 years	(5.05 / Db) – 4.62
	20–80 years	(5.01 / Db) – 4.57
Black Female	24–79 years	(4.85 / Db) – 4.39

Note. Db = Density of Body
Source. Heyward and Stolarczyk (1996)

& Hussey, 1996; French, Werner, Taylor, Hussey, & Jones, 1996; Pritchard, Hawkins, Wiegand, & Metzler, 2008). Safrit and Wood (1995) stated the test bank was "the best source of test items for sport" (p. 421). A Certified Strength and Conditioning Specialist from the National Strength and Conditioning Association evaluated the knowledge test and the objectives of the unit to further establish content validity of the test.

Procedures for Data Collection

A pretest was conducted using the FITNESSGRAM and knowledge test before the implementation of the PSI weight training course to establish baseline measures of fitness and content knowledge. Tests were explained to participants before data collection began. Participants were placed in small groups and went to four different stations to measure height and weight, skinfold measurements, trunk lift, and back saver sit and reach. Once participants completed the four stations, the researchers had the entire class perform the curl-up test, push-up test, and PACER. The class was divided into two groups. One group executed the tests, while the second group counted. Data collectors monitored participants for correct form during tests. Data collectors had previous experience with the FITNESSGRAM in undergraduate and graduate courses. For testing protocol, see FITNESSGRAM testing manual (Meredith & Welk, 2007). After the FITNESSGRAM test components were

administered, participants took the 50-question knowledge test. They had 50 minutes to complete the test. All participants completed the knowledge test in less than 50 minutes, and results of the knowledge test were not given to participants. The PSI weight training course was implemented after baseline measures were established. When the PSI weight training course was completed, posttest data were collected using the same protocol as the pretest.

PSI Weight Training Course

Researchers designed the PSI weight training workbook before implementation of the PSI model. The PSI workbook for the weight training course was designed with the necessary characteristic of self-pacing (Keller, 1968) so that students worked at their own pace. The workbook contained 12 learning modules that students were required to complete in the course (see Table 3). Progression from module to module within the course involved completing readiness drills, comprehension tasks, criterion tasks, and quizzes of the PSI. Comprehension tasks allowed students to demonstrate for a partner their understanding of the critical elements of the task presentation or

Table 3

Personalized System of Instruction Weight Training Modules

Module	Instructional Focus
1	Introduction to Weight Training Terminology of Weight Training
2	Flexibility
3	Barbell Squats Bench Press Crunches Machine Curls Triceps Kickbacks Module Quiz
4	Power Pull Front Raises Standing Calf Raises Barbell Shoulder Shrugs Module Quiz

Table 3 (cont.)

Module	Instructional Focus
5	Leg Press Push Downs Bent Over Rows Lateral Dumbbell Raises Module Quiz
6	Hang Clean Back Extensions Dumbbell Fly Lat Pull Downs Module Quiz
7	Lunges Dumbbell Curls Triceps Extension Machine Overhead Press Module Quiz
8	Push Press Incline Bench Press One Arm Dumbbell Rows E-Z Bar Curls Module Quiz
9	Leg Extensions Incline Dumbbell Press Seated Rows Module Quiz
10	Upright Rows Hammer Curls Triceps Extensions Module Quiz
11	Cardiovascular Training Forms of Cardiovascular Training Calculate Target Heart Rate One Mile Walk Test
12	Weight Training Program Design Weight Training Workout

exercise (Metzler, 2005). Criterion tasks of the PSI model provided opportunities for participants to demonstrate mastery of the skill (i.e., exercise) to meet the corresponding learning objectives of the unit, which were established by the instructor (Metzler, 2005).

In Modules 2 through 11, participants mastered each exercise by completing the comprehension and criterion tasks. Each exercise had a complete description of how to correctly execute the exercise along with illustrations including what muscles were involved. Participants read the material from the workbook and then performed a comprehension task followed by three criterion tasks. The weight training comprehension task required participants to perform the exercise with very little weight to become familiar with the technique. Participants performed the first criterion task by choosing a weight they could lift with correct form. A partner would check their form based on a checklist that had the critical elements of that exercise. The participant had to perform each critical element of the exercise with proficiency to proceed to the next criterion task. The second criterion task had participants find the maximum weight lifted for 10 repetitions. Once participants determined the amount of weight they could lift 10 repetitions, they proceeded to the third criterion task. This third criterion task required participants to determine their one repetition maximum weight by using this formula: maximum weight lifted 10 repetitions divided by 75%. When participants completed the calculation, they proceeded to the next exercise. Participants continued the learning module until they reached the module quiz. The module quiz was an online five-question quiz designed to test participants' knowledge of correct lifting techniques and muscles activated with the exercises in that specific learning module. Participants completed the module quiz online and had to score a 100%. If they did not, they retook the quiz with a 10-minute wait period in between retakes until 100% was achieved. Ten minutes was chosen to allow participants to review material. To minimize cheating, the quiz was timed and, for each trial participant who retook the quiz, there were different questions from a question bank. Once participants completed the learning module, they informed the instructor on the next class day that the module had been completed. The instructor checked the work and signed the participant's workbook. Participants were not allowed to proceed to the next module until the instructor checked off the workbook. When participants reached Module 12, a weight training

program guideline was provided. Guidelines included the correct number of sets and repetitions participants would complete for each exercise. These guidelines provided suggestions in choosing correct exercises, the order of exercises, and the weight load to choose from when designing a personal weight training program. Participants used exercise data from previous modules to help design their own weight training program using the guidelines. They used the weight training program for the remainder of the course.

Intervention Verification

To ensure the instructor was following the PSI model in the weight training course, researchers observed the class once a week throughout the 15-week course. The observations performed followed the PSI teacher and student benchmarks developed by Metzler (2005).

Data Analysis

SPSS 16.0 statistical package (SPSS Inc, Chicago, IL) was used to perform paired-samples *t* tests to compare pretest and posttest scores of the following dependent variables: (a) number of laps on PACER test, (b) number of correctly performed curl-ups on the curl-up test, (c) number of correctly performed push-ups on the push-up test, (d) scores (cm) for the back saver sit and reach test left leg, (e) scores (cm) for the back saver sit and reach test right leg, (f) scores (cm) for the trunk lift test, (g) percentage body fat for body composition, (h) number of correct answers on the knowledge test. A Bonferroni corrected alpha was calculated to be .007.

Results

Descriptive statistics generated on the dependent variables included (a) number of laps on PACER test, (b) number of correctly performed curl-ups on the curl-up test, (c) number of correctly performed push-ups on the push-up test, (d) scores (cm) for the back saver sit and reach test left leg, (e) scores (cm) for the back saver sit and reach test right leg, (f) scores (cm) for the trunk lift test, (g) percentage body fat for body composition, and (h) number of correct answers on the knowledge test at each assessment point in Table 4.

Table 4

Descriptive Statistics for FITNESSGRAM Test and Knowledge Test

Dependent Variable	Pretest	Posttest
PACER test	52.91 (20.87)	53.05 (20.77)
Curl-up test	40.23 (18.01)	42.05 (17.36)
Push-up test	25.55 (12.18)	27.14 (11.66)
Back saver sit and reach right leg test	28.17 (3.40)	28.17 (3.51)
Back saver sit and reach left leg test	27.94 (3.45)	28.17 (3.02)
Trunk lift test	29.31 (3.00)	29.79 (1.78)
Percentage body fat test	15.22 (7.54)	14.13 (7.08)
Knowledge test	30.32 (4.29)	37.00 (3.95)

Note. Mean (SD)

FITNESSGRAM

Paired-samples *t* tests revealed no significant difference between pretest scores and posttest scores for PACER, $t(21) = -.279$, $p > .007$; back saver sit and reach test left leg, $t(21) = -1.449$, $p > .007$; back saver sit and reach right leg, $t(21) = .000$, $p > .007$; and trunk lift, $t(21) = -1.702$, $p > .007$. Paired-samples *t* tests revealed significant increases for number of curl-ups, $t(21) = -4.335$, $p < .007$, and number of push-ups, $t(21) = -5.080$, $p < .007$, and a significant decrease in percentage body fat, $t(21) = 5.722$, $p < .007$.

Knowledge Test

A paired-samples *t* test revealed a significant increase from pretest scores to posttest scores for the knowledge test, $t(21) = -7.247$, $p < .007$.

Discussion

As we age, physical activity declines (National Center for Health Statistics, 2004). To combat this trend, some or many universities are implementing physical activity programs to encourage students to enroll in physical activity courses. These courses may vary from team sport activities (e.g., basketball, softball), to individual sport activities (e.g., tennis, badminton), to fitness-oriented activities (e.g., aerobics, weight training). It is vital that PA programs at colleges and universities effectively develop and promote health-enhancing behaviors, as many college students choose unhealthy

modes of weight loss (NASPE, 2007) and the activity patterns of college students remain static for up to 6 years (Sparling & Snow, 2002). Weight training is an activity that can be utilized throughout one's life. According to the National Strength and Conditioning Association's (NSCA, 2008) position statement, resistance training (i.e., weight training) can produce the following health benefits:

1. Resistance training may enhance cardiovascular health by mitigating several of the risk factors associated with cardiovascular disease by producing changes such as (a) decreases in resting blood pressure, particularly in individuals with elevated pressures; (b) decreases in exercise heart rate, blood pressure, and rate pressure product at a standard workload; (c) modest improvements in the blood lipid profile; and (d) improvements in glucose tolerance and decreases in hemoglobin A1c in patients with diabetes mellitus.

2. Resistance training may result in improvements in body composition by maintaining or increasing lean body mass and producing modest decreases in the relative percentage of body fat.

3. Resistance training can produce increases in bone mineral density and may help delay or prevent the development of osteoporosis by reducing the age-associated loss of bone mineral density.

4. Resistance training may reduce anxiety and depression and may result in improved self-efficacy and overall psychological well-being.

5. Resistance training can reduce the risk of injury during participation in other sports and activities. When performed correctly and properly supervised, it is in itself a safe activity with low injury rates.

6. Resistance training increases muscular strength and endurance, resulting in an increased ability to perform activities of daily living, and reduces demands on musculoskeletal, cardiovascular, and metabolic systems.

Due to the overwhelming benefits of weight training and the importance of effective college/university PA programs, it is important that programs adopt practices to ensure student success.

An instructional model one can choose is the Personalized System of Instruction (PSI). Originally designed for a university psychology course, it has been adopted by many teachers in different fields including physical education (Metzler, 2005).

The PSI model promotes high levels of student learning in physical education settings (Cregger, 1994; Metzler, 1984; Metzler, 1986), but no research has utilized the PSI model in weight training. What made the PSI model unique in this setting was the characteristic of self-pacing. It allowed participants to progress through a weight training course at their own pace. This characteristic is the key feature of the model, as "students progress as fast as they can or as slowly as they need" (Metzler, 2005, p. 217). This characteristic allowed participants who had some experience with weight training to go faster than those who did not have much experience. It allowed the teacher to provide high amounts of direct contact time with students who had minimal experience and to provide such students with high amounts of specific, individual feedback. The PSI weight training model ensured that participants learned correct lifting techniques by holding them accountable. Participants modeled correct lifting techniques to a partner before progressing through the next task of a learning module. Participants learned what muscles were activated during specific weight training exercises. The use of the PSI in the weight training course promoted effective teaching practices, which are vital to student learning (Rink, 2006). This instruction was very different than a traditional weight training course, which has the teacher instruct participants to perform specific exercises a certain number of sets and repetitions, sometimes or often without providing the reasoning of why one would want to execute a specific exercise. The PSI weight training model provided participants with the reasoning of why one chooses a certain exercise to work certain muscle groups. Participants were required to calculate their maximum repetition by performing the maximum amount of weight they could lift in 10 repetitions. After calculating the maximum repetition, participants used the maximum repetition to design their own personal workout routine based on personal goals and guidelines that were provided by the instructor when participants reached Module 12. These guidelines gave participants instruction on the correct sets and repetitions along with exercise order to choose from when designing a weight training program. Instead of telling participants what exercises to perform, number of sets, and

repetitions, participants had to design a personal weight training program with the knowledge gained in the course.

Participants in the current study of the PSI weight training course had significant increases in the curl-up test, push-up test, and knowledge test and a significant decrease in percentage body fat. These student learning effects of the PSI weight training were supported by research conducted with the PSI in a physical education setting (Cregger, 1994; Metzler, 1984; Metzler, 1986). During a bowling unit, Cregger (1994) revealed that university students reported higher student learning in bowling spare conversion. Metzler (1984, 1986) also discovered that student learning increased during a tennis unit that utilized the PSI model.

The PSI weight training course did not have a significant effect on the PACER test, back saver sit and reach test, or the trunk lift test. The PACER test measured the cardiovascular endurance of the participants. The purpose of the weight training course was to provide information and practice in weight training and not cardiovascular exercises. The PSI weight training model provided information about cardiovascular training (i.e., Module 11); it did not allow time for participants to engage in cardiovascular exercises. The physical activity course was a beginner level weight training course designed to teach participants how to perform weight training exercises, design a weight training program, and execute that program during the class.

As for the back saver sit and reach test and the trunk lift test, participants were very flexible before the implementation of the PSI weight training model. The FITNESSGRAM test protocol for the back saver sit and reach test and trunk lift does not allow participants to stretch any farther than 30.48 cm (i.e., 12 in.). Some participants could have stretched farther on the tests, but researchers followed the testing protocol. Different flexibility testing protocols (e.g., American College of Sport Medicine Sit and Reach) should have been chosen to investigate the effects of the PSI weight training course on flexibility.

Conclusion

Metzler (2005) stated that certain models are better suited for certain contexts and content. Based on the design of the PSI and the distinguishing characteristics of self-pacing and mastery-based learning and the findings of this study, the PSI is an ideal

instructional model for fitness and weight training courses. The PSI course promoted student learning and improved weight training-related knowledge and slightly improved select metrics of physical fitness (i.e., push-up and curl-up tests, body fat). Participants were very active during class in learning the correct techniques of each weight lifting exercise. They were able to master the content by being tested for correct lifting form and then being able to identify the critical elements of the exercises along with the muscles that are being activated through online quizzes. The PSI weight training course showed promise of introducing correct lifting techniques, introducing muscles activated, and planning a personal weight training program. With the small sample size and only minimal improvement in the dependent variables, the PSI weight training course should continue to be researched.

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