Learning is the process by which we acquire knowledge about the world, while memory is the process by which that knowledge is encoded, stored, and later retrieved (Kandel, Schwartz, and Jessell 2000). Understanding how individuals learn and retain knowledge is critical for educators, as a more complete understanding of these processes allows one to more effectively convey information to students.

Over the past century a large number of learning theories have been proposed (McCarthy 1980; Gardner 1993; Caine and Caine 1994; Brooks and Brooks 1999). A central tendency among many of these theories is the idea that personal relevance, defined as whether a learner perceives the instruction to satisfy personal needs or to help achieve personal goals, is a critical factor in successful learning. For example, Keller (1987a, 1987b) proposed that relevance is a critical factor in student motivation, which he suggested is a necessary condition for learning. The importance of making course content personally relevant to students is a recurring theme throughout the teaching literature, and has been suggested as an essential ingredient in the learning process (Weaver II and Cotrell 1988; Visser and Keller 1990; Caine and Caine 1994). In general, researchers believe that students need a personally meaningful challenge to most effectively stimulate their mind to the desired state of alertness in order to link new information to prior knowledge in ways that enhance learning and retention (Caine and Caine 1994).

Despite the widespread consensus that personal relevance is a critical factor in effective teaching and successful learning, relatively little empirical evidence exists to support its utility. The authors felt that one way to investigate the role of personal relevance in learning would be to compare how well people retain subject matter that is either closely connected to or distantly associated with activities they engage in. Some research exists to support the idea that relevance and motivation to participate in physical activity are related. Simons, Dewitte, and Lens (2003) found that students in college physical education classes were more motivated to learn a...
double-dribble basketball task when they were given instructions that identified the personal and future relevance of the task. Based on this finding, as well as on the research and theory on relevance and learning already discussed, the present study is rooted in the assumption that high engagement in certain activities (i.e., exercise) suggests more personal relevance than low engagement. The purpose of this study was to examine the role of personal relevance in learning and memory by assessing the level of knowledge retention of exercise physiology content in college students who engage in large amounts of physical activity (athletes) and those who do not (nonathletes). Specifically, the amount of exercise physiology content retained over a four-week time period by athletes and nonathletes was investigated, and it was hypothesized that the athletes would retain exercise physiology-related knowledge to a greater extent than nonathletes. We expected athletes to find exercise physiology content more personally meaningful than nonathletes.

**Methods**

*General overview of the experimental design*

Students enrolled in three nonmajor, undergraduate-level classes at Syracuse University were asked to participate in the study. These classes were not degree-specific requirements, but were rather general survey classes in varying topic areas (i.e., Personal Health and Safety, Freshman Forum, a course designed to help transition students to college life). Those agreeing to participate first completed a 20-question survey (quiz) that was designed to assess their knowledge in the topic area of exercise physiology. After completing the survey, the answers and a brief explanation to each question was provided to the subjects and they were asked to read the material in the next 48 hours. Four weeks after the initial questionnaire was completed subjects were contacted and asked to complete the exercise physiology-related questions again. In addition to the 20-question quiz, subjects were asked to provide information on their level of physical activity and sport participation, and academic achievement level (SAT or ACT score). Based on their self-reported level of exercise/athletic engagement subjects were divided into two categories: athletes (defined as engaging in exercise or sports for more than 7 hours per week [≥ 1 hour per day]) and nonathletes (defined as engaging in exercise or
sports for less than 4.6 hours per week (≤ 40 minutes per day); the study participants were not aware that they were being categorized based on this reported information. Subsequently, group differences in knowledge retention (change in score on the follow-up test vs. the initial test) were assessed. The premise of this study design is based on the assertion that the athletes will find the exercise physiology content more personally relevant than their nonathlete counterparts will. Assuming this is the case and if personal relevance is a factor in knowledge retention, the athletic group should demonstrate a higher degree of retention.

Subjects
A total of 76 subjects enrolled in the study. Five of these subjects were excluded due to their levels of physical activity falling between the ranges defined for the two groups (average daily physical activity ranging between 41 to 59 minutes). Of the 71 remaining subjects, 40 were classified as athletes and 31 as nonathletes. Thirty-five of the athletes and 28 of the nonathletes completed both the initial and follow-up study surveys (study completion rates of 87.5% and 90.3%, respectively). Of the 35 athletes, 19 of these participated in NCAA Division II sports (6 track/cross-country athletes, 3 swimmers, 3 basketball players, 3 field hockey athletes, 2 rowers, 1 volleyball player, and 1 cheerleader). Table 1 provides descriptive statistics of the subjects. Subjects were not informed of the research questions prior to or during the experimental assessments. None of the subjects had previously taken college-level courses in exercise physiology or anatomy and physiology.

Questionnaire and explanations
The assessment questionnaire and explanations were custom-developed and pilot-tested on a total of 12 subjects to ensure clarity. Additionally, validity of the questions and explanations were verified through discussions with three content area experts. Many of the questions were modified versions from the commercially available software accompanying a common undergraduate level exercise physiology textbook (McArdle, Katch, and Katch 2004).

The questions were purposefully designed to be very difficult (pilot testing scores indicated that the majority of scores ranged between 20% and 50%). This high degree of difficulty was chosen to allow room for improvement so as to not create a ceiling effect in the data. In addition to assessing the level of exercise physiology knowledge, the questionnaire inquired about the subject’s age, gender, exercise participation habits, importance of physical activity to them, and SAT or ACT score. ACT scores were converted to an SAT score based on equivalent scores from those with the same percentile ranks for a common group of test takers (Dorans et al. 1997).

An example of a survey question is: Which of the following causes muscle soreness? A. Disruption of muscle cytoskeleton, which results in inflammation; B. Accumulation of lactic acid; C. Depletion of cellular energy storage (ATP); D. Death of nerve cells.

The answer and explanation to this question was as follows:
Correct Answer: A. Disruption of muscle cytoskeleton, which results in inflammation. Explanation: We used to think that muscle soreness was caused by a buildup of lactic acid in muscles, but now we know that lactic acid has relatively little to do with it. Rather, muscle soreness is caused by damage to the muscle fibers themselves. Muscle biopsies (samples of tissue taken from the muscle) taken on the day after hard exercise show bleeding and disruption of the filaments that hold muscle fibers together as they slide over each other during a contraction. The end result is that the damaged muscle tissue swells (due to fluid shifts and the movement of immune system cells into the muscle to aid in repair) and causes pain.

Many people think that cooling down after exercise helps to prevent muscle soreness, but it doesn’t. Cooling down speeds up the removal of lactic acid from muscles, but a buildup of lactic acid does not cause muscle soreness, so cooling down will not help to prevent muscle soreness. Stretching does not prevent soreness either, since postexercise soreness is not due to contracted

| TABLE 1 |

Descriptive statistics of study participants, along with the subjective rating of the thoroughness with which they read the answers and explanations.

<table>
<thead>
<tr>
<th></th>
<th>Mean + SD</th>
<th>Mean + SD</th>
<th>Mean + SD</th>
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<tbody>
<tr>
<td>Athletes (n = 35)</td>
<td>19.5 ± 1.5</td>
<td>1109.4 ± 126.4</td>
<td>16.0 ± 5.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.2 ± 2.3</td>
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<tr>
<td>Nonathletes (n = 28)</td>
<td>19.4 ± 3.8</td>
<td>1122.3 ± 109.4</td>
<td>2.6 ± 1.5</td>
</tr>
<tr>
<td></td>
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<td>4.0 ± 2.2</td>
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Means + SD. *Athletes > Nonathletes.
muscle fibers. However, the use of anti-inflammatory medications (i.e., Advil) does seem to reduce the pain of muscle soreness, but it will not actually speed up the healing process.

Treatment of the data and statistical analysis
To assess the effect of personal relevance on knowledge retention, the total number of correct answers for each subject was calculated on the two different tests (the initial test and the follow-up test) and served as the dependent variable. Next, a repeated measures ANOVA was performed with the between-subjects factor being group (athletes versus nonathletes), and the within-subjects factor being time (initial test assessment versus follow-up assessment). Additionally, this analysis was performed using SAT score, reading thoroughness, and the initial test score as covariates. The preset alpha level of significance was set at $p \leq 0.05$. In addition to the reported $p$-values, effect size (ES, here referring to partial eta squared, which represents the proportion of total variation attributable to the factor partialing out other factors from the total nonerror variation) is reported to aid in interpretation of the findings. All statistical analyses were performed using SPSS (version 10.0).

Results
No differences were observed in age ($p = 0.85, ES < 0.00$) or SAT score ($p = 0.68, ES < 0.00$) between the groups (Table 1). Regardless of group, subjects demonstrated an increased quiz score on the follow-up survey (Figure 1, Time Main Effect: $p < 0.00, ES = 0.62$). However, a differential response between groups on the follow-up quiz was not observed, indicating that the athletes and nonathletes retained the knowledge similarly over time (Figure 1A, Time × Group Interaction: $p = 0.25, ES = 0.02$). Interestingly, the athletes did display a higher overall exam score than the nonathletes when the data are pooled over time (Figure 1A, Group Main Effect: $p = 0.05, ES = 0.06$), indicating that their overall knowledge level of exercise physiology was greater than the nonathletes. When the initial survey score was entered as a covariate the time by group interaction was still statistically insignificant and the effect size remained small (Figure 1B, $p = 0.19, ES = 0.03$). Similar findings were observed when the data were analyzed using reading thoroughness score and SAT score as covariates ($p = 0.28$ and $0.27$, $ES = 0.02$ and $0.02$).

Discussion
The purpose of this study was to examine the difference in knowledge retention between individuals who actively engage in large amounts of physical activity (athletes) and those who do not (nonathletes), with the premise that insight on the role of personal relevance in knowledge retention could be ascertained. Based on the assumption that athletes would find exercise physiology content more personally relevant than nonathletes, it was hypothesized that athletes would retain more exercise physiology-related knowledge than nonathletes when tested on this content. However, results indicated no significant between-group differences in retention; therefore, these findings do not support a relevance-retention relationship.

Previous research on relevance and learning has utilized cross-sectional, interview, observation strategies. These reports have supported the important role of relevance in student motivation (Frymier and Shulman 1995; Simons, Dewitte, and Lens 2003) and student time-on-task (Newby 1991), which have both been tied to student learning and achievement as important mediating factors (Brophy and Good 1986; Zimmerman and Schunk 2001). In this study, knowledge retention was selected as an index of learning, but our findings suggest that relevance has little or no bearing on how much information a person retains.

Several questions must be raised in response to this study's findings. First, there is the question of whether or not subjects were motivated to learn and retain the content on which they were tested. Theoretically, and as shown in the studies by Frymier and Shulman (1995) and Simons, Dewitte, and Lens (2003), relevance and motivation are linked, which implies that the athletes in this study should have been more motivated than the nonathletes to learn the test material. Though we did not directly investigate this relationship, we did notice that the athletes did not read the test answers/explanations with any greater care than the nonathletes, as assessed by our survey question inquiring about how closely they read the provided answers (Table 1). This seems to suggest that motivation was not a factor in this study's findings. It should be noted, however, that there are many sources of intrinsic motivation such as autonomy and competence (Deci and Ryan 2000). Thus, the present study is limited
in the context of it only addressing relatedness as a source of motivation and it is possible that other motivational sources that were not measured may have influenced the findings.

On the other hand, if other sources of motivation were a constant between subjects, then a second question surfaces: Did the athletes indeed find the content more personally relevant than the nonathletes? This study was based on the assumption that athletes would find the content area of exercise physiology more personally relevant than nonathletes. While we feel this assumption makes logical sense, it is possible that either the athletes do not truly find the material relevant or that the nonathletes find it personally meaningful. There is no direct empirical support for the assumption made in the present study; however, indirect evidence can be garnered from the observation that individuals who adhere to exercise behaviors over time internalize their reasons for involvement (Ryan et al. 1997), along with the idea that people can be motivated because they value an activity (Deci and Ryan 2000; Ryan and Deci 2000). As mentioned earlier, some support for this latter idea has surfaced in physical activity settings (Simons, DeWitte, and Lens 2003).

When one considers that the nonathletes in the present study reported engaging in over two hours of physical activity per week, it seems plausible that they may have found exercise physiology a relevant and meaningful content area about which to learn. To confirm the validity of this study’s findings, further investigation is needed to identify whether athletes and nonathletes find relevance in exercise physiology content. Additionally, further work is warranted to investigate if these findings are consistent in other cohorts (e.g., elderly, a different control group that is sedentary, and so on).

In summary, to evaluate the role of personal relevance on memory and learning, we investigated whether athletes retain exercise physiology knowledge to a greater extent than nonathletes. We observed that the longitudinal knowledge retention between the two groups is similar. This finding questions the role of personal relevance in learning and memory.

Acknowledgments

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