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Young investigator
Research article

RESISTANCE TRAINING IMPROVES SLEEP QUALITY IN OLDER ADULTS—A PILOT STUDY

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ABSTRACT
Older individuals, as a group, tend to experience difficulty sleeping compared to younger adults. Improving sleep in the elderly would have beneficial public health consequences. This study utilized 8 sedentary, older adults, 78.1 ± 3.1 years of age, who participated in a six-month long resistance training (RT) program. The Pittsburgh Sleep Quality Index (PSQI) was used to examine sleep quality, and a 1 repetition max test (1-RM) was used to determine upper (bench press) and lower (leg press) body strength. Total strength, defined as the sum of the bench press and leg press 1-RM results, was also reported. The training resulted in significant improvements ($p < 0.05$) in total (19%) and upper body (52%) strength and in sleep quality (38%). Future studies should examine the effects of strength gain/loss and time-of-day training on sleep quality.

KEY WORDS: Chronic disease, resistance training, older participants, strength, sleep.

INTRODUCTION

The process of aging results in many physiological changes. Arthritis, diabetes, cancer, stroke, hypertension, and heart disease are chronic conditions that commonly afflict the elderly. Further, the incidence of most of these conditions, for both men and women ≥ 70 years of age, increased over an 11-year period from 1984 to 1995 (Federal Interagency Forum on Aging-Related Statistics, 2002). Researchers have recently postulated that the incidence of at least 20 chronic disorders can be reduced by regular exercise given that modern lifestyles do not lend themselves to optimal gene expression (Booth et al., 2002). Human beings are endowed with a genetic legacy that evolved to meet the challenges of the hunter/gatherer lifestyle, which is characterized by frequent exercise, famine, and feasts (Booth et al., 2002). In present times the abundance of easily affordable food, coupled with a diminished requirement to exercise, is a situation encountered by many, if not most, Americans. The quality of life in later years in the United States is the focus of ever increasing attention given the shifting demographics toward a society that is becoming increasingly comprised of older citizens (Federal Interagency Forum on Aging-Related Statistics, 2002).

Problems with sleep tend to occur as one gets older (Montgomery and Dennis, 2002) and these phenomena have health ramifications (Schubert et al., 2002). A notable consequence of insomnia, for example, is compromised function during desired waking times (Neubauer, 2003) which is a potentially dangerous condition. For example, chronic insomniacs have 2.5 times more fatigue-related automobile accidents than do good sleepers (Mendelson and Jain, 1995). Monetary concerns also arise as a consequence of poor sleeping; the need to purchase sleeping aides can be cost prohibitive for older adults, many of whom are living on limited income and already shoulder a substantial financial burden for health care costs (Crystal et al., 2000).

Older adults also experience loss of muscle mass and strength as they age (Hunter et al., 2004). Tasks that younger adults take for granted, such as walking and climbing stairs, can be challenging for many senior citizens. A sedentary lifestyle, also common among the elderly, predisposes one to injury thus exacerbating preexisting limited mobility, level of activity, and accelerates the rate of decline of muscular function.

Studies have shown that exercise, under certain conditions, may have beneficial effects upon sleep (Driver and Taylor, 2000), however, the use of exercise as a treatment method (for poor sleep or any ailment), is rare in clinical practice. Indeed, one only has to sample the clinical literature to see examples of physical activity underrepresented or missing altogether as a therapeutic measure for those who suffer from poor sleep (Woodward, 1999; Schneider, 2002; Neubauer, 1999). In regard to the elderly with sleep problems, even in the research literature there is variability in the between-studies average subject age that may limit the extent to which conclusions can be generalized. Further, a previous study has also implicated a time-of-day training effect upon sleep; above a certain exercise threshold, regular exercise in the mornings may promote sleep at night, while the same exercise performed regularly in the evening may retard it (Tworoger et al., 2003).

To the best of our knowledge few studies have been performed that examine the effect of resistance training on sleep in older participants who are not suffering from clinical depression. The present study was designed to determine the effects of a 6-month resistance training (RT) program performed in the mornings on strength and sleep in older participants. We hypothesized that resistance training in these older participants would result in significant improvements in strength and sleep quality.

METHODS

Participants

Eight older residents (≥ age 60) from a local assisted living center completed 6 months of resistance training designed to improve upper and lower body strength. At the initial screening visit, consent was obtained and a medical history was documented. Inclusion criteria included (i) male or female 60 years of age and older, (ii) willingness to participate in a resistance training intervention for 24 weeks, (iii) ambulatory, and (iv) consent of their primary family doctor. Exclusion criteria included (i) any uncontrolled chronic illness, (ii) current exercise volume of more than 1 hour per week, and (iii) currently smoking. Participant description is as follows: 3M/5F; age 78.1 ± 3.1 yr, average body mass index 26.4 ± 1.8 $kg \cdot m^{-2}$ (means ± SE). Participant use of sleeping medication was not pronounced. Of the 8 participants, 6 never used any sleep aides. Of the two that did report the use of sleeping medication at the study onset, their use declined as the study progessed (data not shown). The Texas Tech University Health Sciences institutional review board approved the research protocol.

Resistance Training Protocol

Participants performed 1-circuit resistance training (RT) of bench press, leg press, leg extension, rowing, shoulder press and arm curl at 10-12 reps per exercise. Two minutes of rest was allowed between each exercise. Each training session lasted approximately 30 minutes. Training began at 50% of the one-repetition maximum (1-RM) and was increased as tolerated. Training was performed Monday, Wednesday, and Friday mornings for 24 weeks on site using a Precor ® S3.21 Strength Multi-Station (Woodinville, WA, USA). The shoulder press and arm curl were performed using dumbbells. The training sessions were monitored by a certified fitness trainer.

Measures

At baseline, after 3 months, and after 6 months of RT, each subject performed a 1-RM test to determine upper (bench press) and lower (leg press) body strength. Briefly, the 1-RM was the greatest weight the subject could lift as determined by a stepwise increase in the load. The participants performed the exercise initially using submaximal weight. As the load and perceived difficulty moving the load progressively increased, the target number of repetitions per load decreased. The 1-RM was the weight of the last successful lift.

To determine sleep quality, each participant completed the Pittsburgh Sleep Quality Index (Buysse et al, 1989) at baseline, after 3 months, and after 6 months of RT. The Pittsburgh Sleep Quality Index assesses 7 areas in arriving at a global score: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. The 7 domains are each scored from 0 to 3, with a total or global score ranging from 0-21. A better sleeper would have a lower global PSQI score. The PSQI may have several longitudinal applications in clinical practice and research (Buysse et al, 1989), thus making it a logical sleep assessment tool for this study. Previous studies have used the PSQI to assess subjective sleep quality in the elderly with (Singh et al, 1997; Li et al, 2004) and without (Buysse et al, 1991) multi-week exercise interventions. For the purposes of this study, the use of sleeping medication, a component of the PSQI, and the global PSQI score, were examined.

Statistics

Data were analyzed using SigmaStat for Windows ® Version 2.03. All values are presented as the means ± SE. A one-way repeated measures analysis of variance (ANOVA) was used to examine differences among the three reported 1-RM measurements and also for the sleep data. A Student-Newman-Keuls post hoc test was performed where indicated. Statistical signficance was accepted at $p < 0.05$.

RESULTS

Strength measurements

The average 6-month attendance rate for the protocol participants was 85.4 ± 3.9%. Figure 1 shows mean strength values for the participants. RT yielded a significant increase in total body strength (top panel) at 3 ($p = 0.034$) and 6 months ($p = 0.034$) relative to baseline (22% and 19%, respectively). Upper body strength (middle panel) increased at 3 and 6 months, however this reached statistical significance ($p = 0.011$) only at the 6 month measurement period. RT yielded a 31% and 52% increase in upper body strength at 3 and 6 months, respectively, relative to baseline. No statistically significant changes in lower body strength (lower panel) were detected at 3 and 6 months, however lower body strength was increased by 16% and 9%, respectively.

Sleep measurements

Sleep quality, as measured by the PSQI global score, improved from the beginning of the training period to the three month time point ($p = 0.043$) (Figure 2). The average sleep score was 5.0 at the study onset, and by 3 months the average score was 3.1, a 38% decrease. A decrease in the global PSQI represents an improvement in sleep. The trend of an increasing slope from 3 to 6 months (a partial reversal in the measured sleep improvements noted at 3 months) coincides with the loss of strength gains in lower and total body strength which also occurred from 3 to 6 months as shown in Figure 1.

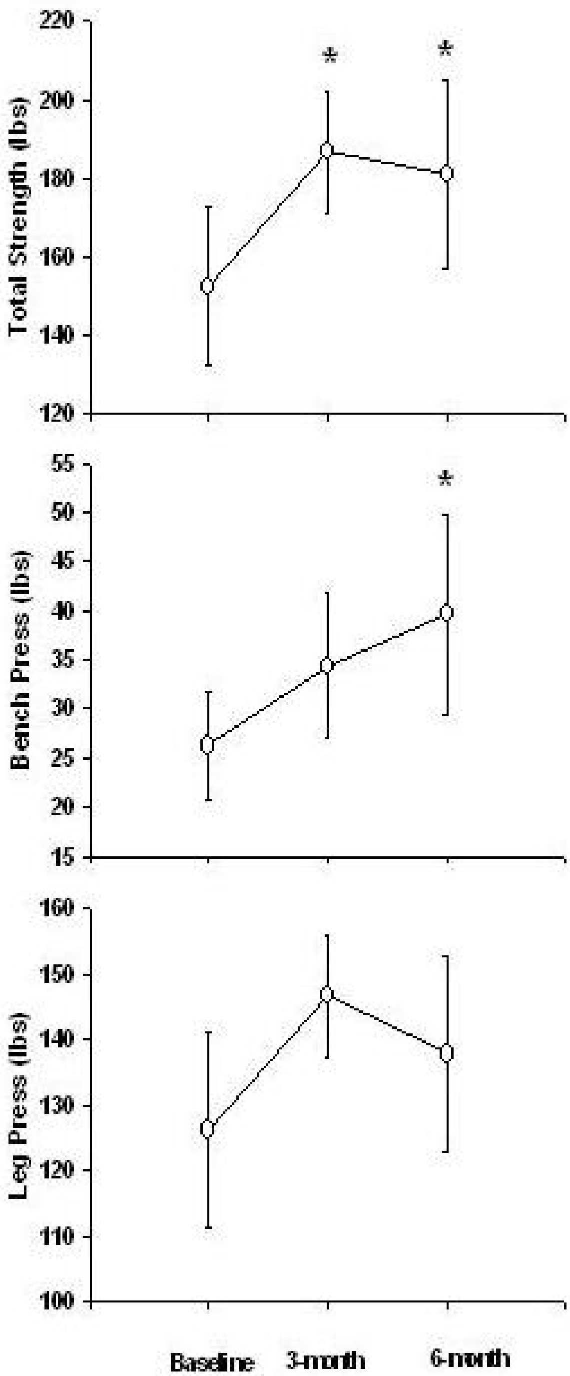

Figure 1. The increase in total strength 1-RM at 3 and 6 months (top graph). Total strength 1-RM represents the contributions from upper body (bench press 1-RM) and lower body (leg press 1-RM). The asterisks at both time points indicate a significant difference ($p < 0.05$) relative to baseline. The increase in upper body strength 1-RM at 6 months (middle graph). Upper body strength was assessed using the bench press 1-RM. The asterisk indicates a significant difference ($p < 0.05$) relative to baseline. Lower body strength (bottom graph) was assessed using the leg press 1-RM.

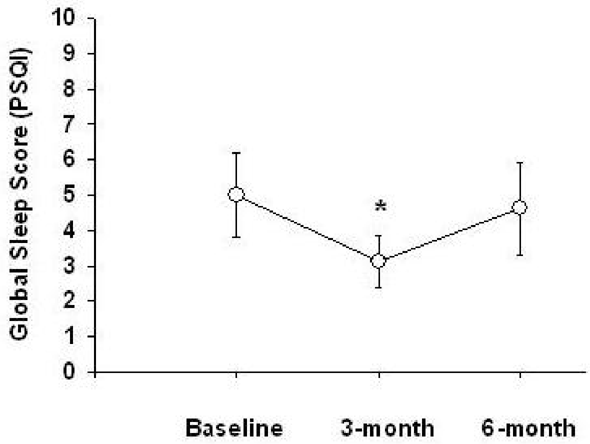

Figure 2. Sleep scores as measured by the PSQI at baseline, 3, and 6 months. There was a significant improvement in the global PSQI at 3 months relative to baseline ($p < 0.05$). The scores for the 6-month sleep assessment were not significantly different from baseline.

DISCUSSION

Previous studies have shown that aerobic exercise training can exert positive effects on sleep quality. A 1997 meta-analysis (Youngstedt et al., 1997) showed that acute exercise increased total sleep time. Likewise, older individuals also benefit from exercise training with respect to sleep quality. A training regimen consisting of low-impact aerobics and brisk walking resulted in improvements in participants' global PSQI scores as well as improvements in various domains which contribute to the global score (King et al., 1997).

Comparatively few studies have examined the relationship between resistance training and sleep as opposed to aerobic-based regimens, and fewer still have examined the effect of resistance training on sleep in older participants. Singh and colleagues demonstrated that a supervised weight-training program performed three times per week for ten weeks yielded improvements in measured subjective sleep quality for a group of depressed, mostly poor sleepers whose average age was 71.3 ± 1.2 years (Singh et al., 1997). Our results are in agreement with Singh et al. and indicate that a regular resistance training program can improve major skeletal muscle strength and sleep in older participants whose average age is near 80, and who are characterized as "good sleepers." The percent changes in strength parameters in the present study are comparable to those reported previously for older adults (Vincent et al., 2002).

This study utilized a multi-station machine (Precor® S3.21 Strength Multi-Station) and dumbbells purchased specifically for the protocol. All equipment was placed in a pre-existing physical fitness facility located at the assisted living center. The average 6-month attendance rate for the protocol participants was 85.4 ± 3.9%. We feel that this approach combines the best aspects of home-based training (no travel required, participants feel at ease) while simultaneously providing a social network and social support that enhances compliance and enjoyment of strength training (Seguin and Nelson, 2003). It is possible that the improvement in sleep was due, to some extent, to the social engagement that occurred while training in the facility's fitness room. However, the results of a study by Morgan (2003) support the possibility that the improvement in sleep was due to the RT alone.

Lower body strength did not improve significantly from the resistance training. This protocol contained 4 exercises that worked upper body muscles; bench press, rowing, shoulder press and arm curl. Two exercises, leg press and leg extension, worked lower body muscles. Since our participants were sedentary, and ambulation, which utilizes the lower limbs, is the common movement in all non-handicapped individuals, we sought to emphasize upper body training. We viewed it as likely that upper body strength in these individuals had diminished more from disuse and therefore warranted an emphasis in resistance training. It is also possible, however, that this emphasis in training led to the disparities in strength gains seen in the lower and upper body regions. Future investigations would be advised to ensure a balanced approach regarding body regions exercised.

It is possible that as gains in strength taper, a corresponding reduction of gain in sleep parameters also occurs. Although our subject pool was not of sufficient size to yield a significant correlation, the graphical trends are clear; from 3 to 6 months the average total strength declined while the average global PSQI increased (worsened) relative to the midpoint. This data is consistent with Singh and colleagues (1997) who reported that increase in strength was a significant predictor of the improvement in the total PSQI among depressed elders.

A topic receiving much attention is the of time-of-day training effect on sleep. Our participants trained only in the mornings. It would be informative if future research with older participants contrasted the effects of an identical training intervention regularly performed in the morning against one done in the evening. Multiple studies are needed to address this issue because it appears that exercise duration, as well as possibly intensity and other factors determine if a given protocol is best performed in the early or latter part of the day with respect to sleep quality.

It is known that acute exercise can lead to a stimulation of growth hormone (GH) secretion (Weltman et al., 2003). It is tempting to speculate that the involvement of GH and growth hormone-releasing hormone (GHRH) subsequent to exercise were causative factors in the noted sleep improvement. This is consistent with the traditional hypothesis that sleep serves body restoration (Driver and Taylor, 2000) and hence exercise will improve sleep. Indeed, it has been suggested that hypothalamic GHRH leads to anabolic restoration via GH release and such activity coincides with a GHRH-induced promotion of NREM sleep (Obal and Krueger, 2001). The resistance training performed in this study may therefore have resulted in an increased pulsatile release of endogenous GH at rest yielding an increased 24-hour secretion. Such an outcome would be consistent with the results from a study of older males who were regular runners and age-matched sedentary controls; the runners had higher resting GH levels (Hurel et al., 1999). However, another study showed that the 24-h GH secretion in older adults does not increase after a year of RT (Hartman et al., 2000), but the authors in a review article (Wideman et al., 2002) acknowledge that more investigation needs to occur before conclusions can be made about the usefulness of RT for elevating GH in the elderly.

There are limitations related to the present study. The participants in this study had an average baseline global PSQI of 5.0. The authors of the paper in which the PSQI was introduced describe a poor sleeper as one who has a global PSQI score of > 5. Hence, the participants for this study, at the onset, are considered to have been "good" sleepers, albeit barely. It is tempting to conclude that a strength training intervention for the very old that do not sleep well would be more beneficial, given the results with same-age good sleepers. Future studies with elderly, poor sleepers are needed to confirm (or disprove) this hypothesis. Additionally, the small sample size limited the power of statistical analysis in this study and no control group was utilized. The number of willing participants at the assisted living center was limited and could be attributed to the fact that there was no remuneration. The constraints of the inclusion and exclusion criteria (see Methods) further restricted the size of the experimental group, and the aforementioned factors likewise precluded the creation of a control group.

CONCLUSIONS

One-circuit resistance training performed three times per week in the morning leads to an improvement in strength and sleep in older participants whose average age is circa 80 years. We suggest future studies are needed to explore the effects of different training times and strength gains/losses upon sleep, as well as to determine the efficacy of such regimens upon individuals who are characterized as poor sleepers.

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KEY POINTS

- Compromised sleep and deterioration of skeletal muscle mass and function are commonly found among the aged.
- Results show that RT led to improvements in upper and total body strength in older participants who trained three times per week in the morning.
- The resistance training led to improvements in sleep as measured by a self-report sleep questionnaire, the Pittsburgh Sleep Quality Index.
- The small sample size used, lack of control group, and the fact that the participants on average were characterized as “good” sleepers at the study onset, necessitates that further investigation occur.
- We suggest that further research is required to explore the effects of RT performed at different times of the day as well as to determine the relationship between sleep gains or losses upon changes in sleep quality.

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