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SCIENTIFIC INVESTIGATIONS

Intention to Exercise in Patients with Obstructive Sleep Apnea

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Obstructive sleep apnea (OSA) is a common and serious health issue that is strongly associated with excess weight. Exercise may be an effective mechanism for reducing the severity of OSA both in association with, and independent of, reduction in body weight. As such, increased exercise has been suggested as a potential intervention for OSA, particularly for patients with mild to moderate clinical severity. However, it is unknown how ready to engage in exercise patients with OSA are. Self-reported exercise intention was assessed in 206 consecutive patients attending a large tertiary sleep disorders service in Australia. Classification of the patients by Stage of Change, a construct of the Transtheoretical Model of behavior change, was supported by differences between the groups in level of habitual self-reported exercise. Cluster analysis identified 4 potential patient types, with differing profiles in perceived costs and benefits of exercise, and exercise-related self-efficacy. The validity of these patient clusters was also supported by differences between the groups in current self-reported exercise levels. The results may help to identify patients who are more likely to engage in increased exercise, and to identify barriers to exercise in patients less inclined to increase their exercise.

Keywords: Obstructive sleep apnea, exercise, intention, transtheoretical model

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Obstructive sleep apnea (OSA) is a common syndrome that has been estimated to affect 4% of middle-aged men and 2% of middle-aged women,[1] with this prevalence increasing with age.[2] The pathophysiology of OSA involves repeated complete or partial obstruction of the upper airway during sleep, with associated brief arousals leading to significant sleep fragmentation. The syndrome is defined by excessive daytime sleepiness or other consequences of sleep disruption such as impairments in cognitive function.[3] The objective severity of OSA is based on the frequency of obstructive apneas and hypopneas per hour of sleep, summarized as the apnea-hypopnea index (or respiratory disturbance index), and measured during overnight polysomnography.

There is evidence that excess weight is a significant risk factor in the development of OSA. For example, a 10% weight gain predicts an approximate 32% increase in the apnea-hypopnea index (AHI) and a 6-fold increase in the odds of developing moderate-to-severe sleep disordered breathing, among persons initially free of OSA.[4] This effect may be related specifically to visceral fat deposition.[5] Significantly, a large population-based, prospective cohort study has demonstrated that weight loss is an effective mechanism for reducing the severity of OSA.[6] Peppard et al[6] found that a 10% loss in weight predicted a 26% decrease in the AHI. Recommendations to lose weight are frequently cited as "conservative" intervention for OSA.[7,8] Thus, minimizing weight gain and promoting weight loss could be a critical strategy in the management of OSA.

Numerous potential strategies for weight loss have been described; however, energy expenditure resulting directly from exercise has been identified as an essential component of all effective weight loss programs.[9] The maintenance of exercise has also been suggested as one of the best predictors of long-term weight maintenance.[10,11] The increase in exercise required to achieve a negative energy balance may be very moderate.[12] Exercise-specific interventions have demonstrated improvements in both subjective and objective measures of sleep.[13] Norman et al[13] evaluated the effects of a 6-month exercise program in the management of individuals with OSA and found significant posttraining improvements in weight, BMI, AHI, total sleep time, sleep efficiency, and arousal index. Subjective quality of life measures also showed significant changes in health status, affective state, and daytime somnolence. Giebelhaus et al[14] reported a significant decrease in the AHI in patients with OSA after a 6-month exercise training program. Importantly, this improvement was achieved without a significant change in body weight. These data suggest that exercise can reduce the severity of OSA directly, without changes in weight and body composition.[14] In support of this view, a recent population-based study has shown an association between increased exercise and reduced severity of OSA that is independent of body habitus.[15] After adjusting for BMI and skinfold measurements, the exercise-OSA relationship presented as a significant trend in reduced odds of OSA with increasing hours of weekly exercise. Consistent with this, self-reported vigorous physical activity for at least 3 hours each week is associated with decreased odds of sleep disordered breathing in a community cohort (the Sleep Heart health Study).[16] Lastly, exercise has been shown to have positive effects on depression and self-rated sleep quality in older adults without OSA.[17,18] Thus, exercise

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can lead to improvements in OSA, both directly and indirectly in association with weight change, and may also result in general improvements in sleep quality.

Despite the potential benefits of exercise to patients with OSA and other sleep problems, patients commonly report they "cannot, will not, or should not" exercise.[19] The psychosocial factors that determine intention to exercise have been described in models of exercise behavior,[20-22] and are consistent with the factors identified in other health behaviors, such as smoking cessation.[23,24] The Transtheoretical Model of behavior change (TTM)[25,26] is one model that is intended to explain and predict determinants of change in health behaviors, including intention to increase habitual exercise.[27] Under the TTM model, behavior change is understood as a potentially cyclical process with defined stages. The exact properties of the stages may vary, but typical examples are described in Table 1.[27] The utility of this model lies in its potential to inform the design of effective interventions to improve exercise in individuals at each stage.

The motivational mechanisms for change in the TTM include the perceived costs of exercise (Cons), the perceived benefits of exercise (Pros), and the patient's self-efficacy (SE) for exercise (that is, their perceived capability and confidence).[28] As such, the perception that the benefits of exercise outweigh the costs of exercise may occur between the pre-contemplation stage and the contemplation and preparation stages. A threshold for self-efficacy may be crossed to proceed to the action stage.[28] Norman and Velicer[29] used cluster analysis to determine empirical "types" in relation to these 3 components of exercise motivation, and found 4 reliable clusters that generally differed in amount of habitual self-reported exercise, and by stage of change. This typology approach has not been applied to an OSA population, but may provide information on appropriate strategies to improve regular exercise in that group. A similar approach to understanding behavior change has recently been applied to adherence to continuous positive airway pressure (CPAP) therapy in patients with OSA.[30-32]

The aim of the present study was to investigate the validity of the TTM for intention to exercise in patients with OSA and to describe the proportion of patients likely to be at each stage of change (SOC). It was expected that patients at a higher stage of change would report engaging in exercise more regularly. A second aim was to determine whether patients with OSA can be meaningfully classified according to their intentions to exercise. It was expected that patient "types" could be identified that also differed in level of habitual self-reported exercise, and in stage of change.

METHODS

Participants

The study participants were recruited from patients attending a public hospital based sleep disorders center in Queensland, Australia, for polysomnographic investigation of probable OSA. The only exclusion criterion was an inability to provide consent and complete the questionnaires. A total of 331 consecutive patients attending the center between February and December 2005 were invited participate in the study. Of these, 255 (77%) patients agreed to participate. Mean age of the participants was 53 y (SD=12 y), mean body mass index (BMI) was 33kg/m^2 (SD=7), and mean respiratory disturbance index (RDI) was 26/hr (SD=25). The majority (68%) of the participants were male.

Table 1—Stages of Change in the Transtheoretical Model

Stage	Intent / Action
Pre-contemplation	No intention to exercise in next 6 months, no action
Contemplation	Serious intent to exercise in next 6 months, no action
Preparation	Serious intent to exercise in next 30 days, some action
Action	Exercise regularly, but for less than 6 months
Maintenance	Exercise regularly, for more than 6 months

Measures

The measures used in this study were selected to assess demographic variables and level of habitual self-reported exercise, and to assess the TTM constructs of exercise-related stage of change decisional balance and decisional balance:

The Decisional Balance Inventory (DBI)

The DBI[29,33,34] consists of 10 items assessing the Pros of exercise, and 10 items assessing the Cons of exercise. Each item is rated on a 5-point Likert scale with written anchors of 1 "not at all important" to 5 "extremely important." The Pros and Cons scales have reported internal consistency coefficients of 0.91 and 0.72.[29]

Self-Efficacy Scale (SE)

Self-efficacy for exercise was assessed with a scale published by Norman and Velicer.[29] The scale items represent situations that may be considered as potential barriers to exercising (e.g., not having time to exercise). Each item is rated on a 5-point Likert scale ranging from 1 "not at all confident" to 5 "extremely confident." The Self-efficacy Scale has a reported internal consistency coefficient of 0.86.

Stages of Change for Regular Exercise (SOC)

The stage of change measure assessed exercise-related intentions and self-reported exercise behavior. Based on a 4-item algorithm,[29] participants were classified into one of the 5 stages of motivational readiness for behavior change (Table 1). The criterion for regular exercise was any planned physical activity that was performed 3 to 5 times per week (20–60 min per session) with the intent to increase physical fitness.

Godin Leisure-Time Exercise Questionnaire (GLTEQ)

Habitual leisure-time exercise level was assessed with the GLTEQ.[35,36] This 4-item questionnaire asks participants to report the number of times per week they engaged in each of strenuous, moderate, and mild levels of exercise (for at least 20 min) in a typical week. A score for each level of exercise, and weighted composite score can be calculated. The test-retest reliability has been reported as 0.64,[36] and the questionnaire can predict variance in exercise behavior.[37]

Epworth Sleepiness Score

The Epworth Sleepiness Scale (ESS[38]) is a widely used questionnaire designed to evaluate a patient's level of habitual sleepiness during the day. The scale comprises eight items that address typical day-to-day situations. Likely sleepiness in each situation, or imagined sleepiness in each situation, is reported. Each item can be rated from 0–3 points (0 = would never doze, 3 = high chance of dozing), with the final score ranging from 0 to 24. The proposed range for normal sleep propensity is 0–10.[39] The ESS has good reported internal consistency,[40,41] and reliability.[40-42]

Sleep Architecture Variables

Sleep architecture variables were assessed with standard clinical polysomnography (PSG), evaluating the following physiologic and respiratory variables: central and occipital electroencephalogram, oblique electrooculogram, submental and tibialis electromyographic activity, electrocardiogram, nasal and oral airflow via nasal pressure transducer and thermistor, thoracic and abdominal excursions with piezoelectric belts, and continuous oxygen saturation. Sleep stage was scored by trained technicians using standard criteria.[43] Apneas and hypopneas were scored using recommended guidelines by trained sleep scientists.[44] Apnea severity measures included the RDI and the percentage of total sleep time spent below 90% blood oxygenation during the overnight PSG ($SpO2 < 90\%$). Measurements of height and weight were recorded and body mass index (BMI) was derived (kg/m^2).

Methods

The study was approved by the Human Research & Ethics Committees of the University of Queensland and The Prince Charles Hospital. Patients were invited to participate in the study on the night of their initial diagnostic sleep study. If they agreed to participate, they read the patient information sheet and signed the consent form and were given the structured questionnaire battery to complete while in the Sleep Disorders Centre. The questionnaires took between 10 and 30 minutes to complete. Completed questionnaires were collected by unit nursing or scientific staff, and stored securely within the Centre.

Data Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS, version 10.0). Concurrent validity of the stage of change questionnaire was assessed with analyses of variance (ANOVA). Mild, moderate, and strenuous self-reported exercise intensity were compared across each stage of change category. Pair-wise comparisons were performed using the Bonferroni adjustment for multiple comparisons to minimize the influence of Type 1 errors. Hierarchical cluster analysis used squared Euclidean distance measures and Ward's minimum variance method[45] to establish homogenous subgroups. Clustering was based on data from the Decisional Balance Index, and Situational Self-Efficacy measure.[29] An initial cluster analysis was performed with the number of clusters unspecified. Inspection of the agglomeration schedule suggested a 4-cluster solution (i.e., there was a clear inflection in the plot of coefficient differences at that point). The cluster analysis was then re-run with 4 clusters specified. The validity of the 4-group solution was explored by comparing subgroup membership across habitual self-reported exercise measures, using ANOVA. Significance was defined as $p = 0.05$ for all tests, unless stated otherwise. Of the 255 patients who agreed to participate in the study, 206 provided fully complete questionnaires. Forty-nine participants provided partially complete questionnaires. Inspection of the incomplete questionnaires suggested random omissions and unscorable responses. These data were conservatively excluded from further analysis. There was no difference in mean RDI (25 events/hr) or BMI (31 kg/m^2) between patients who declined participation and patients who agreed to participate.

RESULTS

The proportion of patients at each of stage of change determined by the SOC for exercise measure[29] is presented in Table

Table 2—GLTEQ Means, Standard Deviations, and LSD Post Hoc Comparisons by Stage of Change

Variable		Stage of Change					ANOVA			Pair-wise
		PC	C	P	A	M	*F*	p	$p\eta^2$	
	n=	40	5	85	20	56				
	%	19	2	41	10	27				
LT Mild	M	3.55	6.60	2.71	2.95	3.66	2.44	**0.048**	0.05	NS
	SDev	4.12	7.89	2.58	2.48	2.66				
LT Moderate	M	0.43	0.40	0.66	1.85	3.04	21.66	**0.00**	0.30	PC/C<P<A<M
	SDev	0.84	0.55	1.31	2.16	2.35				
LT Strenuous	M	0.23	0.00	0.13	0.35	0.93	4.98	**0.00**	0.09	PC/C/P/A<M
	SDev	1.00	0.00	0.53	1.09	1.68				
LT Composite	M	14.80	21.80	12.58	21.25	34.52	17.55	**0.00**	0.26	PC/C/P <A<M
	SDev	16.80	23.33	12.15	10.16	20.39				
Age	M	57.1	42.6	51.5	51.6	52.6	2.69	**0.03**	0.05	C/P<PC
	SDev	10.2	7.3	12.4	10.3	11.8				
Sex	M	1.25	1.00	1.34	1.30	1.36	0.95	0.43	0.02	NS
	SDev	0.44	0.00	0.48	0.47	0.48				

PC = Pre-contemplation (do not exercise regularly and were not seriously considering doing so in the next 6 months), C = Contemplation (do not exercise regularly but were seriously considering doing so in the next 6 months), P=Preparation (do not exercise regularly but were seriously considering doing so in the next 30 days, A = Action (exercising regularly but for less than 6 months) and M = Maintenance (exercising regularly for the past 6 months or more).

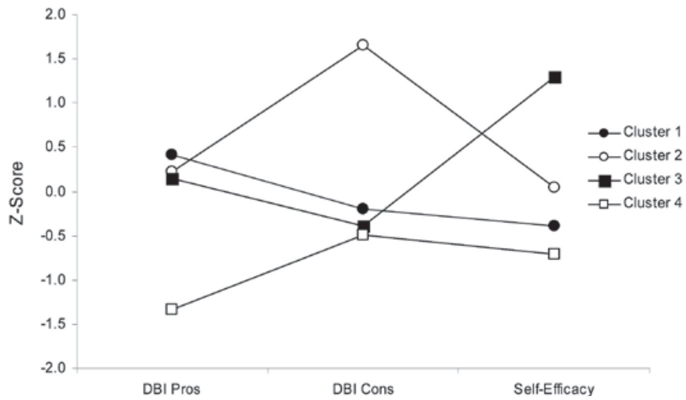

Figure 1—Cluster profiles for four groups derived from hierarchical cluster analysis.

2. The Preparation stage represented the largest category (41%), followed by the Maintenance stage (27%), and then by the Pre-contemplation stage (19%). The results of the ANOVAs presented in Table 2 suggest significant differences across stage of change for the number of times each week the participants reported that they engaged in exercise at each level of exercise intensity (mild, moderate, and strenuous). Pair-wise comparisons were generally consistent with a hierarchy of exercise across stage of change, such that patients at the maintenance stage engaged in more self-reported exercise (at each intensity level), than those at other stages. The $p\eta^2$ statistics, an estimate of effect size, suggested largest effects of stage for moderate levels of self-reported exercise (and then for the composite exercise score).

Mean scores for each of the 4 clusters identified in the cluster analysis are depicted in Figure 1 for the 2 DBI measures (DBI Pros and DBI Con), and the SE measure. Cluster 1 (43% of patients) was characterized by a flat profile, Cluster 2 (16%) had elevated DB Cons, Cluster 3 (22%) reported high self-efficacy for exercise, and Cluster 4 (18%) reported the lowest values for all 3 measures.

To assess the validity of the clusters identified in this analysis, differences between the identified groups on independent measures of self-reported exercise, gross sleep parameters and body mass index (BMI) were assessed by Analysis of Variance (ANOVA). As noted in Table 3, there was no difference between the 4 clusters for the variables of BMI, ESS, RDI, or percent time below 90% saturation. Patients in Cluster 3 reported engaging in significantly more exercise than the other patients (at least at moderate levels of intensity), and were at a higher stage of change for exercise than were the other patients. Patients in Cluster 1 and Cluster 2 were similar on these dimensions, with the patients in Cluster 4 reporting engagement in significantly less exercise than the other patients. No association between participant age and the number of exercise episodes engaged in each week was noted ($r=-0.08$, $p>0.05$)

DISCUSSION

The findings of the present study provide support for the validity of applying the TTM to exercise intention in patients with OSA. Over 60% of the patients were at a pre-Action stage (either Pre-contemplation, Contemplation or Planning stages), with less than 30% reporting that they were at the Maintenance stage. Categorization of patients by stage of change, identified by the SOC for exercise measure, was supported by significant differences in self-reported frequency of exercise at each level of intensity (mild, moderate, and strenuous). That is, patients at the Maintenance stage reported engaging in exercise more regularly than those at the pre-Action stages.

The cluster analysis provided 4 empirical patient types, based on their responses to the DBI and SE measures. Again, this categorization was supported by differences in level of habitual self-reported exercise. Norman and Velicer[29] found support for

Table 3—GLTEQ Scores, PSG Indices, BMI and ESS Scores by Cluster Membership

		Cluster				ANOVA			
Variable		**1**	**2**	**3**	**4**	***F***	**p**	**pη²**	**Pair-wise**
	n=	89	33	46	38				
	%	43.20	16.02	22.33	18.45				
LT Mild	M	3.07	3.27	3.11	3.82	0.53	0.67	0.01	
	SDev	0.34	0.56	0.47	0.52				
LT Moderate	M	1.19	0.88	2.80	0.47	12.63	**0.00**	0.17	3>2=1>4
	SDev	1.74	1.41	2.55	1.13				
LT Strenuous	M	0.47	0.48	0.46	0.00	1.79	0.15	0.03	
	SDev	1.29	1.28	1.15	0.00				
LT Composite	M	19.40	18.58	27.46	13.82	4.33	**0.01**	0.06	3>1=2=4
	SDev	19.47	15.81	19.64	18.22				
LT Frequency	M	1.81	1.79	2.28	1.66	7.24	**0.00**	0.10	3>1=2=4
	SDev	0.68	0.74	0.75	0.53				
*Ex Stage	M	2.30	1.82	3.13	1.31	15.66	**0.00**	0.19	3>1=2>4
	SDev	1.23	1.49	1.09	1.34				
ESS Total	M	11.49	12.03	11.39	10.92	0.27	0.85	0.00	
	SDev	5.21	5.84	5.19	4.98				
PSG BMI	M	32.99	32.20	32.90	31.78	0.32	0.82	0.01	
	SDev	7.47	5.76	8.34	5.54				
PSG RDI	M	26.36	25.75	30.08	22.16	0.70	0.55	0.01	
	SDev	24.80	21.89	30.65	19.77				
PSG %<90SAT	M	9.05	2.72	14.19	8.85	2.44	0.07	0.04	
	SDev	17.91	4.41	27.41	16.92				

4 reliable clusters based on the same measures in a nonclinical population. Interpreting and labelling derived clusters profiles is a subjective procedure; however, the cluster profiles identified here (Figure 1) have some similarities to the 4 clusters described by Norman and Velicer.[29, 46] For example, Cluster 1 is similar to their "early action" group (motivated to exercise but lacking confidence to continue). Cluster 2 is similar to the "immotive" group (rate negative aspects of exercise high, and positive aspects low). Cluster 3 is similar to the "habituated" group (exercise is a well-formed habit, with little decision making required), and Cluster 4 is similar to the "disengaged" group (psychological detachment regarding exercise). As such, the 34% of patients in Cluster 2 and Cluster 4 may lack awareness about exercise, or may have had negative experiences with exercise previously

The potential utility of the cluster grouping lies in the potential to devise interventions to specifically address the constructs of costs, benefits and self-efficacy for exercise for each group. For example, patients in Cluster 2 reported high relative levels of perceived costs for exercise. As such, an intervention to specifically address the barriers to exercise endorsed by these patients (e.g., "Exercise is too boring to do it regularly") may be effective. The evidence for the success of individualized intervention based on the TTM and other similar or competing models is limited.[28] Further research that assesses the impact of patient type on weight change and OSA-related health outcomes is necessary.

A clear limitation of this research is the use of self-report measures of habitual exercise. In general, self-report of physical activity tends to overestimate moderate intensity activity when compared to the double labelled water method, with improved validity for more vigorous activity.[47] This limitation is accepted in the behavior model literature.[28] Objective assessment of daily activity with actigraphy,[48] or with pedometers[49] may provide more reliable data on the level of activity engaged in by patients with OSA. In one patient population, the GLTEQ correlated significantly, but moderately, with both pedometry (0.44), and with Actigraphy (0.52). The correlation between pedometer count and Actigraphy data was more robust ($r = 0.93$).[50] Standardized use of pedometers or actigraphy could provide a low cost metric for comparison of level of exercise in sleep medicine. However, the accuracy and validity of both these objective approaches varies with model and type of device.[51]

Shneerson and Wright[52] note that there are currently no adequate studies that test the effectiveness of lifestyle modification, including increasing exercise and weight loss, for treating OSA. There is a clear need for randomised controlled trials that improve exercise in patients with obstructive sleep apnea. Such trials need to focus not only on OSA indices but also general health outcomes, given the large benefits noted by even modest levels of exercise, and the high levels of cardiovascular comorbidities in OSA patients.

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