Clinical Medicine Insights: Cardiology
Volume 11: 1–23
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DOI: 10.1177/1179546817701725
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Psychological Responses to Acute Aerobic, Resistance, or Combined Exercise in Healthy and Overweight Individuals: A Systematic Review

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ABSTRACT

INTRODUCTION: Psychological distress and depression are risk factors for cardiovascular disease (CVD). As such, a reduction in psychological distress and increase in positive well-being may be important to reduce the risk for future development of CVD. Exercise training may be a good strategy to prevent and assist in the management of psychological disorders. The psychological effects of the initial exercise sessions may be important to increase exercise adherence. The aims of this systematic review were (a) to examine whether acute aerobic, resistance, or a combination of the 2 exercises improves psychological well-being and reduces psychological distress in individuals with healthy weight and those who are overweight/obese but free from psychological disorders, and (b) if so, to examine which form of exercise might yield superior results.
METHODS: The online database PubMed was searched for articles using the PICO (patient, intervention, comparison, and outcome) framework for finding scientific journals based on key terms.
RESULTS: Forty-two exercise studies met the inclusion criteria. A total of 2187 participants were included (age: 18-64 years, body mass index [BMI]: 21-39 kg/m^2). Only 6 studies included participants with a BMI in the overweight/obese classification. Thirty-seven studies included aerobic exercise, 2 included resistance exercise, 1 used a combination of aerobic and resistance, and 2 compared the effects of acute aerobic exercise versus the effects of acute resistance exercise. The main findings of the review were that acute aerobic exercise improves positive well-being and have the potential to reduce psychological distress and could help reduce the risks of future CVD. However, due to the limited number of studies, it is still unclear which form of exercise yields superior psychological benefits.
CONCLUSIONS: Obese, overweight, and healthy weight individuals can exhibit psychological benefits from exercise in a single acute exercise session, and these positive benefits of exercise should be used by health professionals as a tool to increase long-term participation in exercise in these populations.

KEYWORDS: Combined exercise, psychological well-being, single bout

RECEIVED: December 8, 2016. **ACCEPTED:** March 3, 2017.

PEER REVIEW: Five peer reviewers contributed to the peer review report. Reviewers' reports totalled 1355 words, excluding any confidential comments to the academic editor.

TYPE: Review

FUNDING: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: I.L. is supported by Future Leader Fellowship (ID: 100040) from the National Heart Foundation of Australia.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Introduction

Overweight/obesity is reaching epidemic proportions worldwide, where ~40% of the adult population are considered overweight, with 13% classed as obese.[1] In Australia, ~63% of the adult population are classified as overweight or obese (body mass index [BMI] ⩾ 25 kg/m^2), and the number of people living with obesity is expected to rise given the abundance of energy-dense foods and sedentary lifestyle.[2]

The prevalence of major depression in individuals who are obese is ~23%, compared with ~12% in individuals within a healthy weight range (BMI: 19-25 kg/m^2).[3] In addition, individuals who are obese have an increased incidence of mental disorders compared with individuals who are non-obese.[4] The risk of psychological disorders associated with obesity is similar between men and women.[5] The relationship between obesity and psychological disorders is complex and the 2 may be connected via a vicious cycle where obesity can lead to depression, but depression may contribute to changes in lifestyle behaviours that influence body weight.[6] Psychological distress (PD) and depression are risk factors for cardiovascular disease (CVD).[7–9] Exercise has been suggested as a useful tool in treating and managing depression when used in a chronic training regimen.[10–13] However, as many overweight/obese individuals are not involved in exercise regularly, their experience and feelings during the first few exercise sessions are an important factor for long-term adherence.[14,15]

Currently, the most common treatment for depression is the use of antidepressant medication.[16] However, drug therapy is relatively expensive, some people are reluctant to use medications, and they have several side effects, including dry mouth, nausea, constipation, and insomnia.[16,17] Exercise may also be used to prevent and assist in the management of psychological disorders in overweight/obese individuals.[11]

There is some evidence to suggest that a single bout of exercise may improve positive well-being in individuals with major depressive disorders.[18,19] State anxiety has also been reported to improve in major depressive disorders and schizophrenia after a single exercise bout.[20,21]

A single bout of exercise can be referred to as acute exercise. Evidence has shown that acute aerobic exercise can increase positive affect in those who are yet to develop an overt psychological disorder, but further exploration into other modes of exercise is needed.[22] Positive affect in this case is referred to as general self-reported feelings such as pleasure and tension.[22] Clinically, this is important as prevention of a chronic condition may be superior to management of the conditions from both a personal and a public health perspective.[23–25] It is also clinically important to identify what type of exercise, whether it is aerobic, resistance, or a combination of the 2, is superior for improving positive psychological well-being and positive affect. In contrast, it is equally important to identify whether the exercise causes PD or self-reported stress as well as perceived fatigue, so this also can be taken into account when designing an exercise intervention. This might apply in particular to obese individuals whose exercise adherence levels are significantly low with a lack of evidence-based interventions addressing this issue.[26] The intensity of exercise must also be taken into consideration as different intensities can have varying effects on these responses.[27,28]

Therefore, a systematic review was undertaken (a) to examine whether acute aerobic exercise, resistance exercise, or a combination of 2 improves psychological well-being and reduces PD in individuals with healthy weight and those who are overweight/obese, and (b) if so, to examine which form, if any, of exercise might yield superior results.

Methods

Search strategy

The online database PubMed was searched for articles using the PICO (patient, intervention, comparison, and outcome) framework for finding scientific journals based on key terms. Search terms which included both full and abbreviated terms are as follows: (a) (patients) obese, overweight, adult; (b) (intervention) resistance exercise, aerobic exercise, acute, single bout; (c) (comparison) none used; and (d) (outcomes) well-being, anxiety, depression, self-efficacy, exercise perception, quality of life. Combinations of categories (a) to (c) were also used via 'OR' as well as 'AND' to combine the relevant search terms. Manual searches of reference lists in published articles meeting inclusion criteria were also used to locate other related published articles.

Inclusion and exclusion criteria

Studies which met the following criteria were included: (a) the study involved single bouts of exercise, (b) psychological attribute measured both pre- and post-exercise or compared with control, (c) participants aged 18 years or older, (d) minimum BMI of 19 kg/m^2, and (e) observed some form of psychological or mood attribute using a validated questionnaire.

Exclusion criteria included the following: studies that involved a chronic exercise training protocol; age <18 years; participants with an overt cardiovascular or metabolic disease (excluding obesity); musculoskeletal, pulmonary, or neurological conditions; or studies which used animal models.

Risk of bias

Risk of bias was independently performed by 2 authors. The Cochrane Collaboration's tool for assessing risk of bias was used to assess the methodological quality and risk of bias of the studies included in the review. Quality was determined using a descriptive component approach that included items such as the method used to allocate participants into comparable groups; blinding of participants/personnel of interventions and outcomes; outcomes measured in a standard, reliable, and valid way; completeness of outcome data for each main outcome (including attrition and exclusions from the analysis); selective reporting; and any other sources of bias. A summary of risk of bias from each study is provided in Table 1. Any disagreement or uncertainty was resolved by discussion between the 2 authors and senior group researcher to reach a consensus. Using this approach, each study was allocated a risk of bias rating.

Results

In total, 424 studies matching the search criteria were identified. Of these, 386 were excluded based on title, 26 were excluded based on abstract, and 10 were duplicate articles. Manual search of reference lists of articles with appropriate inclusion criteria added 45 studies, where 4 of these were excluded due to abstract not meeting inclusion criteria. One additional study was excluded after review of the full text for not meeting the inclusion criteria. Forty-two studies were accepted for the review (Figure 1). Data from the included studies were extracted by reviewing the results section of the relevant outcome measures, and the pre-post raw data and percentage change was then calculated between 2 measures. As indicated in our risk of bias table (Table 1), only 8 of the 42 selected articles were successfully able to blind participants, personnel, and outcome assessors. This indicates a high risk of bias for most of the selected articles; however, blinding is very difficult to maintain in exercise studies.

Overall, a total of 2187 participants took part in the 42 studies. The mean age was between 18 and 64 years and the mean BMI ranged between 21 and 39 kg/m^2. Only 6 studies included participants with a mean BMI in the overweight or obese classification.[29–32,57,58] The specific protocols and the inclusion and exclusion criteria for each study are described in Table 2.

Thirty-seven studies included aerobic exercise only,[28,31–49,53–55,57–70] and 2 studies included resistance exercise only.[29,30]

Table 1. Risk of bias.

STUDY	ADEQUATE SEQUENCE GENERATION	ALLOCATION CONCEALMENT	BLINDING OF PARTICIPANTS, PERSONNEL, AND OUTCOME ASSESSORS	INCOMPLETE OUTCOME DATA ADDRESSED	FREE OF SELECTIVE OUTCOME REPORTING	FREE OF OTHER SOURCES OF BIAS
Bixby et al. 2001[54]	✓	✓	×	✓	✓	✓
Blanchard et al. 2001[60]	✓	✓	✓	✓	✓	✓
Blanchard et al. 2002[36]	✓	✓	×	✓	✓	✓
Blanchard et al. 2004[61]	✓	✓	×	✓	✓	✓
Boutcher et al. 1997[55]	N/A	N/A	×	✓	✓	✓
Bozoian et al. 1994[33]	×	×	✓	✓	✓	✓
Cox et al. 2001[59]	✓	?	×	✓	✓	✓
Daley & Huffen 2003[57]	?	N/A	×	✓	✓	✓
Daley & Maynard 2003[62]	?	?	×	✓	✓	✓
Daley & Welch 2003[68]	?	N/A	×	✓	✓	✓
Daley & Welch 2004[32]	?	?	×	✓	✓	✓
Dunn & McAuley 2000[37]	✓	N/A	×	✓	✓	✓
Ekkekakis et al. 2000[28]	Protocol 1 (Study III) ✓	N/A	×	✓	✓	✓
	Protocol 2 (Study IV) N/A	N/A	×	✓	✓	✓
Ewing et al. 1984[63]	N/A	✓	×	✓	✓	✓
Focht & Hausenblas 2001[64]	✓	×	✓	✓	✓	✓
Focht et al. 2007[31]	N/A	N/A	×	✓	✓	✓
Gauvin et al. 1997[39]	✓	✓	×	✓	✓	✓
Hansen 2001[38]	✓	N/A	×	✓	✓	✓
Koltyn et al. 1998[69]	?	N/A	×	✓	✓	✓
Lochbaum 2004[58]	✓	×	×	✓	✓	✓
McAuley, 1999[34]	N/A	✓	✓	✓	✓	✓
Nabetani & Tokunaga 2001[41]	✓	N/A	×	✓	✓	✓
Parfitt et al. 2000[40]	N/A	N/A	×	✓	✓	✓
Parfitt & Gledhill 2004[53]	✓	N/A	✓	✓	✓	✓
Petruzzello & Landers 1994[42]	✓	N/A	×	✓	✓	✓
Petruzzello et al. 1997[43]	N/A	N/A	×	✓	✓	✓
Petruzzello & Tate 1997[48]	✓	N/A	×	✓	✓	✓
Plante et al. 2001[44]	N/A	✓	×	✓	✓	✓
Plante et al. 2007[70]	Protocol 1 N/A	✓	×	✓	✓	✓
	Protocol 2 N/A	✓	×	✓	✓	✓

Table 1. (Continued)

STUDY	ADEQUATE SEQUENCE GENERATION	ALLOCATION CONCEALMENT	BLINDING OF PARTICIPANTS, PERSONNEL, AND OUTCOME ASSESSORS	INCOMPLETE OUTCOME DATA ADDRESSED	FREE OF SELECTIVE OUTCOME REPORTING	FREE OF OTHER SOURCES OF BIAS
Rejeski et al 1995[65]	N/A	✓	×	✓	✓	✓
Roth 1989[66]	N/A	×	×	✓	✓	✓
Rudolph & Butki 2008[35]	N/A	?	×	✓	✓	✓
Spence & Blanchard 2001[45]	N/A	✓	×	✓	✓	✓
Szabo 2003[46]	N/A	N/A	×	✓	✓	✓
Treasure & Newbery 1998[47]	N/A	✓	×	✓	✓	✓
Van Landuyt et al. 2000[67]	N/A	✓	×	✓	✓	✓
Watt & Spinks 1997[49]	✓	×	×	✓	✓	✓
Comstock et al. 2013[30]	N/A	✓	✓	✓	✓	✓
Levinger et al. 2009[29]	N/A	✓	✓	✓	✓	✓
Maraki et al. 2005[56]	N/A	N/A	✓	✓	✓	✓
McGowan 1991[50]	?	?	×	✓	✓	✓
Szabo et al. 1998[71]	?	?	?	×	?	✓

✓ indicates 'yes'- low risk of bias, ? indicates unclear – not enough information provided in the publication, × indicates 'no' – high risk of bias, n/a indicates this assessment was not applicable for this study type.

One study used a combination of aerobic and resistance exercise,[56] and 2 studies compared the effects of acute aerobic exercise versus the effects of acute resistance exercise.[50,71]

Aerobic exercise sessions were conducted for a total time ranging between 5 and75 minutes, at intensities varying from 50% to 85% peak heart rate (HR_{peak}), and one to exhaustion.[69] The exercise mode varied and included a cycle ergometer, recumbent bike, Stairmaster stepper, treadmill, and rowing ergometer (Table 2).

For resistance exercise sessions, there were some variations in the volume and intensity. One study used 2 to 3 sets of 2 to 5 repetitions at 59% 1 repetition maximum (1RM) and 1 set of 1 to 2 repetitions at 81% 1RM.[29] The other study used 3 sets of 10 repetitions at 85% to 95% 10RM.[30] Rest between sets was between 60 and 90 seconds[29,30] (Table 2).

The study combining the 2 forms of exercise consisted of 10 minutes of warm-up, 20 minutes of aerobic exercise (aerobics), 20 minutes of muscle-conditioning exercise, and 10 minutes of cool-down[56] (Table 2). The intensities of the exercises were not reported; however, using the Borg Rating of Perceived Exertion (RPE) scale of 6 to 20, the median RPE for the morning aerobic exercise was 13.0 and 13.3 for evening session. The median RPE for the morning resistance exercise was 15 and 13.5 for evening session. This indicates that the exercise was of moderate intensity.

The aerobic exercise components of the 2 comparative studies consisted of 60 to 75 minutes of aerobic dance, running, or karate with intensities not reported. The resistance exercise consisted of 60 to 75 minutes of 'body-building/weight training', but intensities were not reported[50,71] (Table 2).

Fifteen studies used the Subjective Exercise Experiences Scale (SEES),[29,32,34,35,37,40,45,48,49,53,57,59,60,68,71] 10 used the Exercise-Induced Feeling Inventory (EFI),[31,33,36,37,39,47,61,64,65,71] and 6 used the Positive and Negative Affect Schedule (PANAS).[42,54–56,62,65] Twenty-five studies used multiple psychological measurements which reported positive well-being (PWB), positive affect, PD, negative affect, or fatigue[28–31,33–37,39,40,42–45,47,48,54,55,64,65,67,69–71] (Table 2). Increases in PWB and positive affect are considered a positive result, whereas increases in PD, negative affect, or fatigue are negative.

Aerobic exercise

Twenty-eight studies (Table 3) reported that acute aerobic exercise increased PWB (range: 1%-67%).[28,32,34–40,43–45,47,49,53,54,57–65,67,68,70] Two studies reported that aerobic exercise increased PWB in participants with 'high self-perceived efficacy', but one study reported PWB to be reduced in participants with 'low self-perceived efficacy' (34%)[33] and the other study reported an increase in those with 'low self-perceived efficacy'.[34] In this study, self-perceived efficacy was determined prior to exercise by completing a self-efficacy scale measuring the participant's confidence in completing 45 minutes of aerobic exercise at 70% of their maximum capacity.[33] The second study used deliberate incorrect feedback of the scores for

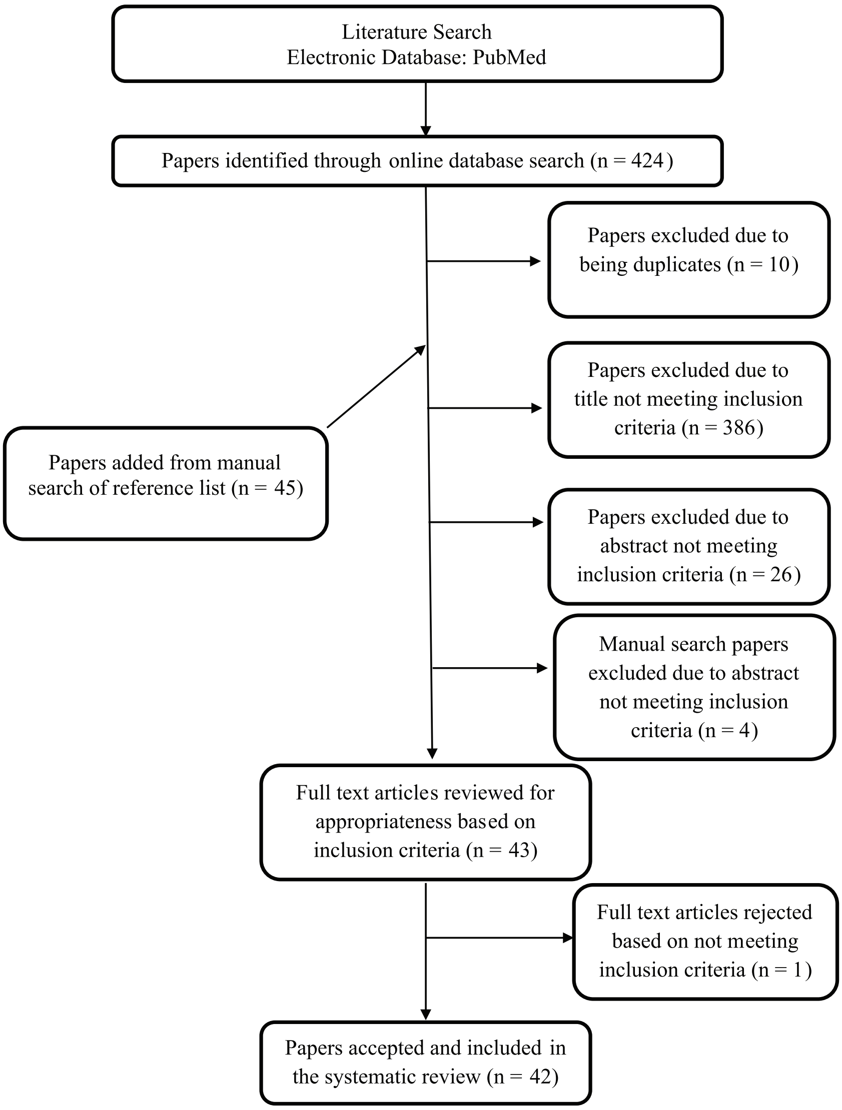

Figure 1. Procedure for identifying and selecting studies related to psychological effects of single bouts of exercise.

individuals' self-efficacy to create a 'high self-efficacy' and 'low self-efficacy' group.[34] Two studies reported PWB to decrease immediately post-exercise compared with pre-exercise.[48,55] Six studies reported no changes in PWB following exercise in both healthy young and older populations.[31,40,42,46,66,70]

Fifteen studies reported that acute aerobic exercise reduced PD post-exercise by 16% to 39% compared with pre-exercise.[32,35,37,41–43,45,46,54,55,58,59,63,66,68] Two studies also reported PD to decrease during exercise from pre- to post-exercise,[40,64] and 1 study reported a decrease immediately post-exercise versus pre-exercise compared with a control group.[49] In contrast, 4 studies reported that aerobic exercise increased PD by 20% to 37%, post-exercise versus pre-exercise.[48,53,60,67] Two studies reported both an increase and a decrease in PD between multiple protocols.[28,70] One study reported PD to increase compared with a control and self-selected exercise group.[62] Another study reported changes in PD following exercise were dependent on the individual perception of self-efficacy, where participants whose self-efficacy was increased reported less PD than those whose self-efficacy was reduced.[34] Four studies reported no significant changes in PD,[44,57,65,69] and 1 study reported no changes in those with low initial PD.[40]

The effect of aerobic exercise on perception of fatigue was variable; acute aerobic exercise decreased fatigue by 6% to 42% following exercise,[32–34,37,38,40,45,48,59,67] whereas others report increases of 2% to 1.4-fold compared with baseline.[31,44,47,49,53,57,60,69] One study reported perception of fatigue to decrease (26%) pre- to post-exercise compared with controls.[61] One study reported perception of fatigue to increase as exercise intensity increased, where at 50% heart rate reserve (HRR) (2%-16%) and at 80% HRR (4%-23%) fatigue increased.[60] A similar study reported perception of fatigue to decrease (36%) during a 50% HRR condition but increase (2%) during an 85% HRR condition.[36] A study also reported perception of fatigue to varying depending on intensity of exercise as well as pre-exercise levels of fatigue.[39] Five

Table 2. Protocols for Included Studies.

REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS	PARTICIPANT CHARACTERISTICS MEAN AGE ± SD (YR) MEAN BMI ± SD (KG·M²)	PARTICIPANT INCLUSION AND EXCLUSION CRITERIA	EXERCISE PROTOCOL	PSYCHOLOGICAL MEASURES INVESTIGATED	PSYCHOLOGICAL MEASURE TIME POINTS
AEROBIC EXERCISE STUDIES					
Bixby et al. 2001[54] Randomized-cross over study n = 27	Male: Age: 23.6 ± 3.3 BMI*: 23.43 Female: Age: 23.1 ± 3.8 BMI*: 21.09	**Inclusion** - Non-smokers - Right hand dominant -University students **Exclusion** - N/R	- 30mins recumbent bike at 75% ventilatory breakpoint (mean HR 118.6bpm) and ventilatory breakpoint (mean HR 158.7bpm)	- VAMS - PANAS	Pre-exercise (baseline), 10, 20, 30mins during-ex and recovery (VAMS), 20mins during-ex & recovery (PANAS)
Blanchard et al. 2001[60] Randomized crossover study n = 24	Highly Fit Age: 23.4 ± 4.7 Unfit Age: 24.8 ± 7.7 Highly Fit BMI*: 21.8 (SD not reported) Unfit BMI*: 20.9 (SD not reported)	**Inclusion** - Female - Unfit: exercised <6 times (total) during past 6 months - Fit: exercised ≥ 5 times per week during past 6 months **Exclusion** - N/R	- 30mins cycle ergometer at either 50% or 80% HRR	- SEES	Pre-exercise (baseline) and post-ex once HR returned to ±10bpm of baseline
Blanchard et al. 2002[36] Randomized controlled study n = 60	15min, 50% HRR: Age: 22.33 ± 8.55 BMI**: 21.74 (SD not reported) 30min, 50% HRR: Age: 25.92 ± 11.27 BMI**: 20.10 (SD not recorded) 15min 85% HRR: Age: 20.92 ± 2.84 BMI**: 21.46 (SD not reported) 30min 85% HRR: Age: 20.33 ± 3.52 BMI**: 20.07 (SD not reported) Control: Age: 20.42 ± 3.75 BMI**: 21.95 (SD not reported)	**Inclusion** - Physically active: exercising 3-4 times per week for previous 6 months **Exclusion** - N/R	- Cycle ergometer 15 min & 30mins 50% HRR, 15min & 20min 85% HRR	- EFI - 0 – 100% self-efficacy scale	Pre-exercise (baseline), exactly halfway during-ex each condition, post-ex once HR returned to baseline levels
Blanchard et al. 2004[61] Mixed-model factorial design study n = 69	Age: 26.52 ± 8.53 Mass: 57.87 ± 4.04	**Inclusion** - Regularly running for at least 20mins per session x 3 per week **Exclusion** - N/R	- 20 & 40min running at 70% HRR - 40min control session	- EFI	Pre-exercise (baseline) and post-ex once HR returned to ±10bpm of baseline (exercise conditions), immediately post-control session
Boutcher et al. 1997[55] Case control study n = 27	Trained: Age: 20.64 ± .77 (SE) BMI*: 20.52 (SD not reported) Untrained: Age: 20.00 ± .51 (SE) BMI*: 24.25 (SD not reported)	**Inclusion** - Trained runners from university track and cross-country team **Exclusion** - N/R	- 30mins total treadmill running, 10 mins at RPE 10 with HR < 115bpm, 10mins at RPE 13 with HR < 145bpm and 10mins at RPE 16 with HR < 175bpm	- PANAS - FS	Pre-exercise (baseline), 5 & 10mins into each condition, 5 & 10mins post-ex

Table 2. (Continued)

REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS	PARTICIPANT CHARACTERISTICS MEAN AGE ± SD (YR) MEAN BMI ± SD (KG·M²)	PARTICIPANT INCLUSION AND EXCLUSION CRITERIA	EXERCISE PROTOCOL	PSYCHOLOGICAL MEASURES INVESTIGATED	PSYCHOLOGICAL MEASURE TIME POINTS
Bozoian et al. 1994[33] Case control study n = 36	Age: 18.0 ± 0.1 BMI: N/R High Efficacy Mass: 60.5 ± 2.3 kg Low Efficacy Mass: 57.0 ± 1.8 kg	**Inclusion** - Female - University undergraduate students **Exclusion** - N/R	- Separated into two groups by results of SES - 7mins warm up then 20min cycle ergometer at 70% HRR	- SES - EFI	Pre-exercise (baseline), 15mins during-ex and 10mins post-ex
Cox et al. 2001[59] Randomized controlled trial n = 24	Age: 28.3 ± 8.3 BMI: N/R	**Inclusion** - History of engaging in ≥ 3 exercise sessions of vigorous intensity for 30-60mins **Exclusion** - Sedentary - Exercised vigorously for >90mins daily - Using hypertension, epilepsy or depression medication	- 30mins running treadmill or stepper at either 50% or 75% predicted VO_{2max}	- SEES	Pre-exercise (baseline) and 5, 10mins post-ex
Daley & Huffen 2003[57] Case controlled study n = 30	Male: Age: 31.6 ± 10.7 BMI*: 25.47 (SD not reported) Female: Age: 30.5 ± 7.2 BMI*: 26.04 (SD not reported)	**Inclusion** - Physically active for 20-30mins ≥ 3 times per week in past 3 months - Members of community health and fitness club **Exclusion** -N/R	- 20mins on cycle ergometer at 40% or 70% HR_{max}	- SEES	Pre-exercise (baseline), 10mins during-ex and 5mins post-ex
Daley & Maynard 2003[62] Within-participants repeated measures n = 26	Male: Age: 35.3 ± 7.55 Mass: 75.4 ± 12.1 Female: Age: 31.1 ± 4.5 Mass: 69.7 ± 8.5	**Inclusion** - Physically active (participate in exercise ≥ 3 times per week) **Exclusion** - N/R	- 30mins at 70-85% age-adjusted HR_{max} using preferred exercise mode, or 30mins at 70-85% HR_{max} cycle ergometer	- PANAS	Pre-exercise (baseline), 15mins during-ex, 5mins post-ex
Daley & Welch 2003[68] Within-participants case control study n = 16	Active Group: Age: 20.1 ± 1.6 Mass: 66.6 ± 6.0 Inactive Group: Age: 20.1 ± 1.2 Mass: 70.2 ± 10.5	**Inclusion** - Female - University students - Active: exercise ≥ 3 times per week, ≥ 20mins, ≥ 6 months - Inactive: exercise ≤ 1 session per week for 20mins **Exclusion** - N/R	-Treadmill running at 50-55% and 80-85% VO_{2max} for 20mins	- SEES	Pre-exercise (baseline), 10mins during-ex, 5mins post-ex

(Continued)

Table 2. (Continued)

REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS	PARTICIPANT CHARACTERISTICS MEAN AGE ± SD (YR) MEAN BMI ± SD (KG·M²)	PARTICIPANT INCLUSION AND EXCLUSION CRITERIA	EXERCISE PROTOCOL	PSYCHOLOGICAL MEASURES INVESTIGATED	PSYCHOLOGICAL MEASURE TIME POINTS
Daley & Welch 2004[32] Case controlled study n = 23	Male: Age: 23.5 ± 0.5 BMI*: 26.60 (SD not reported) Female: Age: 21.4 ± 1.0 BMI*: 25.42 (SD not reported)	**Inclusion** - Recreationally active ≥ 30mins, ≥ 3 times per week, ≥ 6 months **Exclusion** - N/R	- Cycle ergometer for 15mins and 30mins at RPE 12-13	- SEES	Pre-exercise (baseline), exactly halfway during both 15 & 30min conditions, 5mins, 30mins, 1hr & 2hr post-ex
Dunn & McAuley 2000[37] Randomized cross-over study n = 42	Age: 20.0 ± 1.86 Mass: 62.22 ± 13.82 Body fat %: 26.84 ± 6.27	**Inclusion** - Low-active females based on total calories per kg body weight per week. **Exclusion** - N/R	- 20mins walking or jogging on treadmill (based on target HR) at 60% VO_{2peak}, - 20mins walking or jogging at 80% VO_{2peak}	- SEES - EFI - CS	Pre-exercise (baseline), 10mins during-ex, immediately post-ex, 20mins post-ex
Ekkekakis et al. 2000[28] **Protocol 1** Case-control study n = 69 **Protocol 2** Case-control study n = 42	**Protocol 1 (Study III)** Age: 22.0 (SD not reported) BMI: N/R	**Inclusion** - Undergraduate students **Exclusion** - N/R	- 15mins treadmill walking where mean RPE: 9.9 ± 1.9	- FS - FAS - SAM-A - SAM-V - AG-V - AG-A - AD ACL	Pre-exercise (baseline), 8, 15mins during-ex, immediately post-ex, 10mins post-ex
	Protocol 2 (Study IV) Age: 20.0 (SD not reported) BMI: N/R	**Inclusion** - Undergraduate students **Exclusion** - N/R	- 10mins treadmill walking where mean RPE: 9.6 ± 2.3	- SAI - AD ACL	Pre-exercise (baseline), 5,10mins during-ex, immediately post-ex, 15mins post-ex
Ewing et al. 1984[63] Case-controlled study n = 52	Age: 22.4 ± 4.4 BMI: N/R	**Inclusion** - At least high school education **Exclusion** - N/R	- 5mins of treadmill jogging at 65-70% HR_{max}	- POMS	- Pre-exercise (baseline), immediately post-ex & 1.5hrs post-ex
Focht & Hausenblas 2001[64] Randomized cross-over study n = 50	Age: 19.9 ± 1.6 Low SPA group BMI: 24.1 ± 2.9 High SPA group BMI: 20.9 ± 1.5	**Inclusion** - Female - Individuals scoring ≥ 36 and ≤ 22 on SPAS **Exclusion** - N/R	- 20mins on preferred aerobic exercise equipment at preferred level of exertion	- STAI - EFI	Pre-exercise (baseline), immediately post-ex, 30mins post-ex
Focht et al. 2007[31] Case control study n = 18 (Young) n = 15 (Older)	Young Group: Age: 24.1 ± 3.4 BMI: 26.1 ± 3.8 Older Group: Age 64.2 ± 6.5 BMI: 25.9 ± 2.8	**Inclusion** - Sedentary (≤ 2 x 20 min bouts of structured exercise within the last 6 months) - Healthy - Not obese (BMI <28) - Caucasian **Exclusion** - N/R	- Graded VO_{2peak} cycle ergometer - 20min stationary cycling at 65% VO_{2peak}	- FS - FAS - EFI - A four-item self-efficacy questionnaire	Pre-exercise (baseline), 10mins during-ex, and immediately post-ex

Table 2. (Continued)

REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS	PARTICIPANT CHARACTERISTICS MEAN AGE ± SD (YR) MEAN BMI ± SD (KG·M^2)	PARTICIPANT INCLUSION AND EXCLUSION CRITERIA	EXERCISE PROTOCOL	PSYCHOLOGICAL MEASURES INVESTIGATED	PSYCHOLOGICAL MEASURE TIME POINTS
Gauvin et al. 1997[39] Randomized case control study n = 72	Male: Age: 35.70 ± 6.39 Body fat %: 16.14 ± .71 (SE) Female: Age: 37.73 ± 5.66 Body fat %: 21.54 ± .73 (SE)	**Inclusion** - English speaking individuals between 25-40yrs old - Individuals reporting ≤ 1 bout of vigorous exercise in past month **Exclusion** - Those at risk of cardiovascular or orthopaedic complications arising from vigorous exercise	- 30min cycle ergometer at either 30%, 50% or 70% HRR	- EFI - FS	Pre-exercise (baseline), 10mins post-ex
Hansen et al. 2001[38] Repeated measure design study n = 14	Age: 20-26 (SD not reported) BMI: N/R	**Inclusion** - Female college students **Exclusion** - Males - Individuals with contraindications to aerobic exercise	- Cycle ergometer at 60% VO_{2max} for either 10, 20 or 30mins	- POMS	Pre-exercise (baseline), 10mins post-ex
Koltyn, et al. 1998[69] Case-controlled study n = 16	Age: 23.0 ± 3.0 BMI*: 23.36 (SD not reported)	**Inclusion** - Male **Exclusion** - N/R	- Incremental Tests: Cycle ergometer until participants couldn't maintain 75RPM for 3sec, increasing Watts each 2mins - Power Tests: Cycle ergometer at peak power (W) participants had maintained in previous test	- STAI - POMS	Pre-exercise, (baseline), 15mins post-ex
Lochbaum et al. 2004[58] Randomized cross-over study n = 53	Active: Age: 24.35 ± 3.54 BMI*: 22.89 (SD not reported) Inactive: Age: 23.35 ± 3.84 BMI*: 26.53 (SD not reported)	**Inclusion** - Active participants engaged in exercise ≥ 3 times per week, 45mins over past 6 months. - Inactive participants required to have no cardiovascular or other fitness training in past 6 months **Exclusion** - N/R	- 30min treadmill run at either 50-55% VO_{2max} or 70-75% VO_{2max}	- AD ACL	Pre-exercise (baseline), 5, 15 & 25mins during-ex, 10 & 20mins post-ex
McAuley et al. 1999[34] Randomized controlled trial n = 46	Age: 20.4 ± 2.8 High Efficacy BMI: 23.6 ± 4.4 Low Efficacy BMI: 22.3 ± 2.7	**Inclusion** - Low to moderately active women where reporting to be sedentary or exercising <3 times per week qualifies. - College women **Exclusion** - N/R	- 20mins Stairmaster exercise machine at moderate-hard intensity RPE scale 12-16.	- CS - FS - SEES	Baseline, immediately post-manipulation, pre-exercise, 10mins during-ex, and immediately and 15mins post-ex

(Continued)

Table 2. (Continued)

REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS	PARTICIPANT CHARACTERISTICS MEAN AGE ± SD (YR) MEAN BMI ± SD (KG·M²)	PARTICIPANT INCLUSION AND EXCLUSION CRITERIA	EXERCISE PROTOCOL	PSYCHOLOGICAL MEASURES INVESTIGATED	PSYCHOLOGICAL MEASURE TIME POINTS
Nabetani & Tokunaga 2001[41] Randomized within-subject design n = 15	Age: 23.4 ± 1.5 BMI: 22.2 ± 2.5	**Inclusion** - Male graduate students - Healthy individuals **Exclusion** - N/R	- 10 & 15min treadmill run at self-selected intensity	- MCL-S1	Pre-exercise (baseline), 6 & 10mins during-ex, ≤ 2mins post-ex
Parfitt et al. 2000[40] Within-subject crossover design n = 26	Male Age: 21.25 ± 3.62 Female Age: 19.93 ± 1.27 BMI: 23.2 ± 2.8	**Inclusion** - Self-reported active individuals - Healthy - Undergraduate students **Exclusion** - N/R	- 20mins treadmill running at 65% VO_{2max} - 20mins treadmill running at self-selected intensity	- SEES - IMI	Pre-exercise (baseline), 5, 10, 15 & 20mins during-ex, 5mins post-ex
Parfitt & Gledhill 2004[53] Randomized crossover study n = 20	Age: 20.6 ± 1.5 Male BMI: 24.9 ± 3.3 Female BMI: 20.9 ± 2.2	**Inclusion** - Low active people (<2 sessions per week) **Exclusion** - N/R	- Either 20mins cycle ergometer, Concept II rower or treadmill 70% HR_{max}, reporting preferred mode of exercise, using favourite and least favourite mode	- SEES	Pre-exercise (baseline), 5, 10, 15, 20mins during-ex and 5mins post-ex
Petruzzello & Landers 1994[42] Randomized cross-over study n = 16	Age: 22.7 ± 2.4 BMI*: 23.48 (SD not reported)	**Inclusion** - Participate in vigorous exercise ≥ 2 times per week **Exclusion** - N/R	- 15 or 30mins treadmill running at 75% VO_{2max}	- SAI - PANAS	Pre-exercise (baseline), immediately, 5, 10, 20 & 30mins post-ex
Petruzello et al. 1997[43] Case-controlled study n = 30	Active Group: Age: 21.6 ± 4.2 BMI*: 23.72 (SD not reported) Inactive Group: Age: 19.6 ± 1.3 BMI*: 23.99 (SD not reported)	**Inclusion**: - Undergraduate students - Active: ≥ 20mins, 3x per week, ≥ 6 months - Inactive: No exercise for past 6 months **Exclusion**: - N/R	- Cycle ergometer for 24mins at RPE 13	- SAI - SEES	Pre-exercise (baseline), 6, 12, 18mins during-ex, immediately, 6, 12, 18, 24, 30mins post-ex
Petruzzello & Tate 1997[48] Randomized cross-over study n = 20	Age: 22.6 ± 3.3 Mass: 67.4 ± 9.26	**Inclusion** - Right handed - University students **Exclusion** - N/R	- 30mins cycle ergometer at 55% VO_{2max} and 75% VO_{2max}	- AD ACL - SAI	Pre-exercise (baseline), 5, 15 & 25mins during-ex, immediately, 5, 10, 20 & 30mins post-ex
Plante et al. 2001[44] Case Control Study n = 136	Age: 18.94 ± 1.32 BMI: N/D	**Inclusion** - Psychology students - Participants had no injury or physical disability **Exclusion** - N/R	- 30mins cycle ergometer 60-70% HR_{max} either with or without being able to talk to another person	- AD ACL - M-C SDS	Pre-exercise (baseline), immediately post-ex

Table 2. (Continued)

REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS	PARTICIPANT CHARACTERISTICS MEAN AGE ± SD (YR) MEAN BMI ± SD (KG·M²)	PARTICIPANT INCLUSION AND EXCLUSION CRITERIA	EXERCISE PROTOCOL	PSYCHOLOGICAL MEASURES INVESTIGATED	PSYCHOLOGICAL MEASURE TIME POINTS
Plante et al. 2007[70] **Protocol 1:** Case-controlled study n = 128 **Protocol 2:** Case-controlled study n = 88	**Protocol 1** Age: 18.54 ± 1.02 BMI: N/R	**Inclusion** - Female - Undergraduate university students **Exclusion** - N/R	- 20mins cycle ergometer at 60-70% HR_{max}, alone, with stranger or with close friend	- M-C SDS - AD ACL - PACES	Pre-exercise (baseline), immediately post-ex
	Protocol 2 Age: 19.31 ± 0.94 BMI: N/R	**Inclusion** - Female - Undergraduate university students **Exclusion** - N/R	- 20mins either walking on treadmill with or without friend, or walking around university campus with or without friend, all at 60-70% HR_{max}	- AD ACL - PACES	Pre-exercise (baseline), immediately post-ex
Rejeski et al. 1995[65] Case control study n = 80	Age: 18.3 ± 0.1 Body fat %: 25.90 ± 0.45	**Inclusion** - Moderately fit - Females - University students **Exclusion** - N/R	- 10, 25 or 40mins of cycle ergometer at 70% HRR	- PANAS - EFI - FS	Pre-exercise (baseline), 20mins post-ex
Roth 1989[66] Case controlled study n = 80	Age: 20.8 ± 3.5 BMI: N/R	**Inclusion** - University students - Aged <35yrs - Free from any known cardiovascular disease **Exclusion** - N/R	- 20mins cycle ergometer at HR between 115 – 135bpm	- POMS	Pre-exercise (baseline), 15mins post-ex
Rudolph & Butki 2008[35] Randomized controlled trial n = 36	10 min condition: Age: 21.2 ± 2.0 Mass: 61 ± 6.8 kg 15 min condition: Age: 20.3 ± 1.3 Mass: 62.6 ± 6.9 kg 20 min condition: Age: 20.5 ± 1.1 Mass: 62 ± 6.9 kg	**Inclusion** - Actively engaged in regular aerobic exercise ≥ 3 times per week for 20min over the past 6 months **Exclusion** - Unhealthy	- 10, 15 or 20mins treadmill running at RPE 13	- EES - SEES	Pre-exercise (baseline), 5 and 20mins post-ex
Spence & Blanchard 2001[45] Randomized control case study n = 92	Pre-Post Exercise Group: Age: 20.35 ± 4.18 BMI*: 22.05 (SD not reported) Post-Only Exercise Group: Age: 19.52 ± 2.15 BMI*: 23.36 (SD not reported)	**Inclusion** - Moderately active - University students **Exclusion** - N/R	- 12mins cycle ergometer, 4mins at 110 – 120bpm, 130 – 140bpm, 150 – 160bpm	- SEES - CS	Pre-exercise (baseline), immediately post-ex
Szabo 2003 (pilot study excluded)[46] Case-controlled study n = 32	Age: 20.3 ± 2.4 BMI*: 23.68 (SD not reported)	**Inclusion** - Female university students **Exclusion** - Male	- Treadmill run/jogging at self-selected intensity for 20mins	- POMS	Pre-exercise (baseline), 5mins post-ex

(Continued)

Table 2. (Continued)

REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS	PARTICIPANT CHARACTERISTICS MEAN AGE ± SD (YR) MEAN BMI ± SD (KG·M²)	PARTICIPANT INCLUSION AND EXCLUSION CRITERIA	EXERCISE PROTOCOL	PSYCHOLOGICAL MEASURES INVESTIGATED	PSYCHOLOGICAL MEASURE TIME POINTS
Treasure & Newbery 1998[47] Randomized case control study n = 60	Male: Age: 23.17 ± 10.5 Mass: 190.7lbs Female: Age: 22.5 ± 4.7 Mass: 146.4lbs	**Inclusion** - Sedentary, no regular exercise in the past 6 months - Undergraduate students **Exclusion** - N/R	- 15mins cycle ergometer at either 45-50% HRR or 70-75% HRR	- EFI - CS	Pre-exercise (baseline), immediately & 15mins post-ex
Van Landuyt 2001[67] Case control study n = 82	Age: 19.9 ± 1.4 BMI*: 23.31 (SD not reported)	**Inclusion** - University students **Exclusion** - N/R	- 30mins cycle ergometer at 60% VO_{2max}	- FS - FAS - AD ACL	Pre-exercise (baseline), 7, 12, 17, 22 & 27mins during-ex, immediately, 10 & 20mins post-ex
Watt & Spinks 1997[49] Randomised-cross over study n = 28	Age: 33.93 ± 9.12 BMI*: 22.53 (SD not reported)	**Inclusion** - Habitual exercisers: ≥ 3 session per week, ≥ 20mins aerobic exercise - Sedentary: <3 exercise sessions per week **Exclusion** - Any contraindications to exercise	- 20mins cycle ergometer at 60% VO_{2max}	- SEES	Pre-exercise (baseline), immediately post-ex & 90mins post-ex
RESISTANCE EXERCISE STUDIES					
Comstock et al. 2013[30] Between-subject design n = 19	Lean Group: Age: 20.1 ± 2.1 BMI: 22.8 ± 1.4 WHO 1 Group: Age: 21.6 ± 2.5 BMI: 32.3 ± 1.6 WHO 2/3 Group: Age: 20.0 ± 1.4 BMI: 39.4 ± 2.8	**Inclusion** - Sedentary men (not participated in resistance training ≥ 6 months or any structured training regime >2 per week at a length of 30mins per session) **Exclusion** - Any cardiovascular, endocrine, metabolic disease, other acute or chronic disease - Using medications or dietary supplements - Smoker - Lost >2.3 kg at any time 3 months pre-study - Completed resistance training for at least 6 months or any structured training regimen for 30mins, >2 per week	- BMI classed as lean, WHO 1 or WHO 2/3 - 85-95% 1RM, 3 sets of 10 repetitions - Free weight resistance exercises	- 10cm line Likert "Pain and Soreness" scale - 10-point Likert "Fatigue" scale - 10-point Likert "General Soreness" scale	Pre-exercise (baseline), immediately and 24hr post-ex
Levinger et al. 2009[29] Cross sectional study n = 45	Age: 51.4 ± 1.7 Male BMI: 29.1 ± 1.0 Female BMI: 26.7 ± 1.2	**Inclusion** - People with obesity (waist circumference ≥ 94 cm for men, 80cm for women)	- 45-50mins resistance exercise (2-3 sets at ~59% 1RM, 10 repetitions)	- SEES - SF-36	3-5mins pre-exercise (baseline) and immediately post-ex

Table 2. (Continued)

REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS	PARTICIPANT CHARACTERISTICS MEAN AGE ± SD (YR) MEAN BMI ± SD (KG·M²)	PARTICIPANT INCLUSION AND EXCLUSION CRITERIA	EXERCISE PROTOCOL	PSYCHOLOGICAL MEASURES INVESTIGATED	PSYCHOLOGICAL MEASURE TIME POINTS
		Exclusion - Pre-existing cardiac disease - Involved in regular aerobic exercise (>90 mins per week) for past 6 months - Involved in resistance training in past 5 years	- Final set at ~81% 1RM - 60-90sec rest between sets - 90-120sec rest between exercises		
COMBINATION EXERCISE STUDY					
Maraki et al. 2005[56] Controlled crossover study n = 12	Age: 28.0 ± 6.4 BMI: 21.3 ± 1.6	**Inclusion** - Healthy - Female - Aged 18-45 years - BMI between 19-25 kg·m^{-2} **Exclusion** - Contraindications to exercise - Pregnancy - Smoking - Regular exercise (≥3 times per week) - On a special diet	- 10mins warm-up, 20mins aerobic exercise, 20mins resistance exercise, 10mins cool-down	- PANAS	Pre-exercise (baseline) and post-ex
COMPARITIVE EXERCISE STUDY					
McGowan et al. 1991[50] Case controlled study n = 72	Age: N/R (college students) BMI: N/R	**Inclusion** - College students **Exclusion** - N/R	75mins session of either: - Karate - Weight training (3x10 reps) - Run minimum of 2 miles and walk remainder of time	- POMS	Pre-exercise (baseline) & immediately post-ex
Szabo et al. 1998[71] Case-Control n = 195	Aerobic Males: Age: 33.3 ± 8.4 BMI*: 22.8 (SD not reported) Aerobic Females: Age: 25.9 ± 8.9 BMI*: 23.0 (SD not reported) Anaerobic Males: Age: 28.6 ± 10.2 BMI*: 23.2 (SD not reported) Anaerobic Females: Age: 25.9 ± 9.1 BMI*: 20.8 (SD not reported)	**Inclusion** - Habitual Exercisers - College students **Exclusion** - N/R	- 60-75mins either anaerobic exercise (body-building) or aerobic (dance) exercise, martial arts, tai-chi/yoga or control	- EFI - SEES	5mins pre-exercise (baseline), 5mins and 3hr post-ex

Abbreviations: AD ACL, Activation-Deactivation Adjective Checklist; AG-A, Affect Grid Arousal; AG-V, Affect Grid Valence; BMI, body mass index; BMI*, mean BMI determined from published mean height and weight; BMI**, mean BMI determined from published mean height and weight; and converted from imperial to metric measures; bpm, beats per minute; CS, 100% confidence scale; during-ex, during exercise; EES, Exercise Efficacy Scale; EFI, Exercise-Induced Feeling Inventory; FAS, Felt-Arousal Scale; FS, The Feeling Scale; HR, heart rate; HR_{max}, age-predicted heart rate maximum; HRR, heart rate reserve; IMI, Intrinsic Motivation Inventory; MCL-S1, Mood Checklist Short-form 1; M-C SDS, Marlowe-Crowne Social Desirability Scale; N/R, not reported; PACES, Physical Activity Enjoyment Scale; PANAS, Positive and Negative Affect Scale; post-ex, post-exercise; POMS, Profile of Mood States; RPE, the Borg Rating of Perceived Exertion; rpm, revolutions per minute; SAI, State Anxiety Inventory; SAM-A, Self-Assessment Manikin Arousal; SAM-V, Self-Assessment Manikin Valence; SE, standard error; SEES, Subjective Exercise Experiences Scale; SES, Self-Efficacy Scale; SF-36, 36-Item Short Form Survey; SPA, Social Physique Anxiety; SPAS, Social Physique Anxiety Scale; SSE, Specific Self-Efficacy Scales; STAI, State-Trait Anxiety Inventory; VAMS, Visual Analog Mood Scale; VO_{2max}, maximum pulmonary oxygen uptake; VO_{2peak}, peak pulmonary oxygen uptake

Table 3. Exercise effects on psychological attributes.

STUDY	PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT	PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY	FATIGUE
AEROBIC EXERCISE STUDIES			
Bixby et al. 2001[54]	Low intensity condition: • VAMS score significantly ↑ (p < .05) at 20 & 30mins into exercise & post-ex vs baseline High intensity condition: • VAMS score significantly ↓ (p < .05) during-ex & post-ex vs baseline • PA significantly ↑ (p < .01) during-ex compared to pre-ex in both intensities	Low intensity condition: • NA scores significantly ↓ (p < .05) during & post-ex vs baseline High intensity condition: • NA scores did not change significantly (p >.05) during-ex vs baseline • NA scores significantly ↓ (p < .05) post-ex vs baseline	• Not Measured
Blanchard et al. 2001[60]	50% HRR vs 80% HRR: • PWB ↑ (p < .01) in 50% HRR intensity protocol vs 80% HRR protocol, participant group not indicated Pre-ex vs post-ex: • PWB ↑ (p < .01) post-ex vs pre exercise in all conditions Changes included: • 50% HRR = ↑ ~17% fit group, ~6% unfit group • 80% HRR = ↑ 13% fit group, ~2% unfit group • Control = ↑ 4% fit group, 5% unfit group	Post exercise vs pre exercise: • PD ↑ ~37% (p < .05) in 80% HRR intensity condition for unfit group vs pre-ex • No significant change (p >.05) for any other condition in either classification vs pre-ex	Exercise vs control: • Fatigue ↑ (fit group ~4%, unfit group 23%) (p < .05) in 80% HRR intensity group vs control 50% HRR group (fit group ~16%, unfit group 2%)
Blanchard et al. 2002[36]	• PA ↑ ~31% (p < .05) post-ex vs pre-ex in both 50 & 85% intensities	• Not Measured	• Fatigue ↓ ~ 36% (p < .05) post-ex vs pre-ex in 50% intensity condition • Fatigue ↑ ~2% (p < .05) post-ex vs pre-ex in 85% intensity condition
Blanchard et al. 2004[61]	25 min running condition: • PA ↑ 67% (p < .05) post-ex vs control 40 min running condition: • PA did not change significantly (p > .05) vs control	• Not Measured	25 min running condition: • No significant change (p = .10) vs control 40 min running condition: • Fatigue ↓ ~26% (p < .05) from pre to post-ex vs control
Boutcher et al. 1997[55]	Trained group: • PA ↑ (p < .001) in both medium & high intensity during-ex vs pre-ex • PA did not change (p > .05) between trained and untrained post-ex Untrained group: • PA ↓ (p < .05) at 5 & 10mins post-ex vs pre-ex	Trained group: • NA did not change (p > .05) during & post-ex vs pre-ex Untrained group: • NA ↓ (p < .01) during & post-ex vs pre-ex	• Not Measured
Bozoian et al. 1994[33]	High-efficacy group: • PWB ↑ 34% (p < .05) post-ex vs pre-ex Low-efficacy group: • PWB ↓ 34% (p < .05) post-ex vs pre-ex	• Not Measured	High-efficacy group: • Fatigue ↓ ~24% (p < .01) post-ex vs pre-ex Low-efficacy group: • Fatigue ↓ ~6% (p < .01) post-ex vs pre-ex

Table 3. (Continued)

STUDY	PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT	PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY	FATIGUE
Cox et al. 2001 [59]	Post exercise vs pre exercise: • PWB ↑ 9% (p = .04) between 5mins and 60min post-ex vs pre-ex • ↑ 10% (p = .02) at 60mins post-ex vs pre-ex • No change between exercise modes (η2p=0.003).	Post exercise vs pre exercise: • PD ↓ ~22% (p = .04) at 5min post-ex vs pre-ex • ↓ 29% (p = .005) at 30min post-ex vs pre-ex • PD ↓ ~35% (p = .001) at 60min post-ex vs pre-ex • No change between modes (η2p=0.001)	Post exercise vs pre exercise: • Fatigue ↓ ~21% (p = .007) at 60mins post-ex vs pre-ex • No change between pre-ex and 5mins post-ex (p = .73) • No change between pre-ex and 30mins post-ex (p = .33) Change in ex modes: • Fatigue ↑ 27% (p < .025) on stepper vs treadmill
Daley & Huffen 2003[57]	• PWB ↑ ~18% (p < .05) post-ex vs during-ex in 70% HR_{max} condition • PWB ↑ ~13% & 16% (p < .05) post-ex vs during & pre-ex respectively for both conditions on means	• No significant changes (p > .05)	• Fatigue ↑ (p < .01) post-ex and during-ex vs pre-ex in 70% HR_{max} condition
Daley & Maynard 2003[62]	• PA ↑ (~4%, ~1%) (p = .01) post-ex in choice of exercise and control vs no choice cycle egrometry condition	• NA ↑ (~41%, ~36% & ~50%, ~36%) (p = .05 & p = .01) at 15 mins during-ex & 5mins post-ex for cycle ergometer vs control and choice of exercise conditions • NA ↓ (p = .01) at 15 mins during-ex vs pre-ex	• Not Measured
Daley & Welch 2003[68]	Low Intensity vs High Intensity Groups: • PWB ↑ ~19% (p < .01) during-ex in low intensity group vs. high intensity group High Intensity Group: • PWB ↑ ~30% (p < .01) post-ex vs pre-ex • PWB ↑ ~28% (p < .01) post-ex vs during-ex	• PD ↓ ~34% (p < .01) post-ex vs pre-ex • PD ↓ ~16% (p < .01) post-ex vs during-ex	• No significant changes (p > .05)
Daley & Welch 2004[32]	• PWB ↓ ~15% (p < .01) during ex vs 5mins post-ex • PWB ↑ ~23% (p < .01) 2hrs post-ex vs pre-ex	• PD did not change (p > .05) during-ex vs pre-ex • PD ↓ (24%) (p < .01) 5mins post-ex vs during-ex • PD ↓ (32%) (p < .01) 2hrs post-ex vs baseline • PD did not change (p > .05) between 5min, 30min, 1hr and 2hrs post-ex	• Fatigue ↓ (21% & 16%) (p < .01) 30mins & 1hr post-ex vs 5mins post-ex • Fatigue ↓ ~33% (p < .01) 2hrs post-ex vs baseline • Fatigue did not change (p > .05) between 5min, 30min, 1hr and 2hrs post-ex
Dunn & McAuley 2000[37]	• PWB ↑ ~15% (p < .001) 20mins post-ex vigorous condition vs pre-ex • PA ↑ ~20 & 25% (p < .001) immediately & 20mins post-ex moderate condition vs pre-ex • PA ↑ ~21% (p < .001) 20mins post-ex vigorous condition vs pre-ex	• PD ↓ ~25% (p < .001) at 20mins post-ex moderate condition vs pre-ex • PD ↓ ~21% (p < .001) at 20mins post-ex vigorous condition vs immediately post-ex	• Fatigue ↓ (~24%, 21% & 27%) (p < .001) during, immediately post & 20mins moderate condition post-ex vs pre-ex • Fatigue ↓ ~15% (p < .001) 20mins vigorous condition post-ex vs immediately post-ex • Exhaustion ↓ (~ 27%, 33% & 42%) (p < .001) during, immediately post-ex & 20mins moderate condition post-ex vs pre-ex

(Continued)

Table 3. (Continued)

STUDY	PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT	PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY	FATIGUE
Ekkekakis et al. 2000[28]	**Protocol 1 (Study III)** • PA ↑ ($p < .001$) immediately post-ex vs pre-ex • SAM-V & AG-V Valence did not change significantly ($p > .05$)	• NA ↑ ($p < .001$) immediately post-ex vs pre-ex • NA ↓ ($p < .001$) 15min post-ex vs pre-ex	• Not Measured
	Protocol 2 (Study IV) • PA ↑ ($p < .001$) immediately post-ex vs pre-ex • PA ↓ ($p < .001$) 15mins post-ex vs immediately post-ex	• NA ↑ ($p < .001$) immediately post-ex vs pre-ex • NA ↓ ($p < .001$) 15mins post-ex vs pre-ex • SA ↓ ($p <.001$) immediately & 15mins post-ex vs pre-ex	• Not Measured
Ewing et al. 1984[63]	• PA ↑ ~5% ($p < .05$) 1.5hrs post-ex vs pre-ex • PA ↑ ~4% ($p < .05$) immediately post-ex vs pre-ex • PA ↑ ($p < .05$) 1.5hr post-ex exercise group vs control group post-ex	• NA ↓ ~39% ($p < .0005$) 1.5hrs post-ex vs immediately post-ex • NA ↓ ~14% immediately post-ex vs pre-ex	• Not Measured
Focht & Hausenblas 2001[64]	• PA ↑ ~32% & 34% ($p < .001$) 5mins post-ex vs pre-ex & control • PA ↑ ~21% ($p < .001$) 30mins post-ex vs pre-ex & control	• SA ↓ ~18% ($p < .001$) 30mins post-ex vs pre-ex	• No significant changes ($p > .05$)
Focht et al. 2007[31]	• No change ($p < .57$) (↑~7% younger group, ↓~10% older group)	• Not Measured	<u>Post exercise vs pre exercise:</u> • Fatigue ↑ 27% ($p < .01$) in young adults post-ex vs pre-ex • ↑ ~81% ($p < .01$) in older adults post-ex vs pre-ex
Gauvin et al. 1997[39]	• PA ↑ ($p < .05$) immediately post-ex vs pre-ex	• Not Measured	<u>30% HRR:</u> • No significant changes in low intensity group ($p > .05$) 50% HRR: • Fatigue ↓ ($p < .05$) immediately post-ex vs pre-ex in high initial fatigue • Fatigue ↑ ($p < .05$) immediately post-ex vs pre-ex in low initial fatigue 70% HRR: • Fatigue ↓ ($p < .05$) immediately post-ex vs pre-ex
Hansen et al 2001[38]	• PA ↑ ($p < .014$) at post-ex vs pre-ex • PA ↑ ($p < .01$) at 10min during-ex vs pre-ex	• NA ↓ ($p < .007$) at 10min during-ex vs pre-ex	• Fatigue ↓ ($p < .013$) at 10mins during-ex vs pre-ex
Koltyn et al. 1998[69]	• PA ↑ ~38% ($p < .05$) pre-ex for evening-ex vs. morning-ex sessions in power protocol	• No significant changes ($p > .05$)	• Fatigue ↑ ~54% & 50% ($p < .05$) during both AM & PM sessions post-ex vs pre-ex, in power protocol
Lochbaum et al. 2004[58]	• PA ↑ ($p < .05$) post-ex vs during & pre-ex • PA ↑ ($p < .001$) during 55% VO_{2max} condition vs 75% VO_{2max} condition	• AC ADL uses a score of PA vs NA balance, where as PA increases NA decrease and vice versa. PA was reported to increase; NA is therefore reported to decrease ($p < .05$)	• Not Measured

Table 3. (Continued)

STUDY	PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT	PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY	FATIGUE
McAuley et al. 1999[34]	High vs low efficacy group: • PWB ↑ (p < .02) in high efficacy group at all time points vs low efficacy group Post exercise vs pre exercise: • PWB ↑ (high efficacy 26%, low efficacy ~16%) (p-values not indicated) post-ex vs pre-ex	High vs low efficacy group: • PD ↑ (p < .01) in low efficacy group vs high efficacy group during and post-ex	High vs low efficacy group: • Fatigue ↓ (p < .01) in high efficacy group vs low efficacy group across all time points
Nabetani & Tokunaga 2001[41]	• Not Measured	• NA ↓ (p = .02) at post-ex vs pre-ex in 10min condition • NA ↓ (p < .01) at post-ex vs pre-ex in 15min condition	• Not Measured
Parfitt et al. 2000[40]	Preferred vs prescribed exercise pre & post ex: • PWB did not change (p > .05) post-ex vs pre-ex in either condition Low Initial PWB vs High Initial PWB during ex: • PWB ↑ ~17% (p < .05) 15mins during-ex vs 5mins during-ex in prescribed exercise with low initial PWB	High initial PD: • PD ↓ (p < .01) from 5 to 20mins during-ex and 5mins to post-ex in those with high initial PD Low initial PD: • No significant changes (p > .05)	• Fatigue ↓ (p < .01) lower in high initial fatigue at 5 & 10mins during-ex vs low initial fatigue High initial Fatigue: • Fatigue ↓ ~16% (p < .01) from 5 to 20mins during-ex Low initial Fatigue: • No significant changes (p > .05)
Parfitt & Gledhill, 2004[53]	Post exercise vs pre exercise: • PWB ↑ ~7% (p < .01) post-ex vs pre-ex	• PD ↑ ~20% (p < .01) from 5mins to 20mins during-ex	• Fatigue ↑ (p < .01) at 15min, 20min during & post-ex vs pre-ex, 5mins & 10min during-ex
Petruzzello & Landers 1994[42]	• No significant changes (p > .05)	• SA ↓ (~16%, 23%, 26%) (p < .001) 10, 15 & 20mins respectively during-ex vs pre-ex	• Not Measured
Petruzzello et al. 1997[43]	• PA ↓ (p < .01) post-ex & during-ex vs pre-ex for non-active group	• No significant change (p = .58) in SA • NA ↑ (p < .01) post-ex & during-ex vs pre-ex for non-active group	• Fatigue ↓ (p < .001) 12, 18 & 24mins post-ex vs pre-ex overall
Petruzzello & Tate 1997[48]	• PA ↑ (p < .05) post-ex vs pre-ex in 70% condition	• PD ↓ (p < .05) at 30mins post-ex vs pre-ex in 70% condition	• Not Measured
Plante et al. 2001[44]	• PA ↑ (p < .05) post-ex vs pre-ex in all participants • PA did not change (p > .05) between exercising alone & exercising with another	• No significant changes (p > .05)	• Fatigue ↑ (p < .05) in those who participated in exercise with another vs exercising alone
Plante et al. 2007[70]	**Protocol 1** • No significant changes (p > .05)	• NA ↑ (p < .05) immediately post-ex vs pre-ex	• Not Measured
	Protocol 2 • PA ↑ (p < .05) immediately post-ex vs pre-ex	• NA ↓ (p < .05) immediately post-ex vs pre-ex	• Not Measured
Rejeski et al. 1995[65]	• PA ↓ (p < .03) post-ex vs pre-ex in 10 & 25min exercise conditions • PA ↑ (p < .03) post-ex vs pre-ex in 40min exercise condition	• No significant changes (p < .10)	• Not Measured

(Continued)

Table 3. (Continued)

STUDY	PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT	PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY	FATIGUE
Roth 1989[66]	• No significant change (p > .05)	• PA ↓ ~32% (p < .0006) post-ex vs pre-ex in exercise conditions (including both active/inactive participants)	• No significant change (p > .05)
Rudolph & Butki, 2008[35]	Post exercise vs pre exercise: • PWB ↑ ~9% (p < .05) at 20mins post-ex vs pre-ex in all conditions	Post exercise vs pre exercise: • PD ↓ ~23% (p < .05) from pre-ex to 20mins post-ex in all conditions	• No significant changes (p > .05)
Spence & Blanchard 2001[45]	• PWB ↑ (p < .001) in both exercise conditions vs control conditions post-ex	• PD ↓ (p < .001) in both exercise conditions vs control conditions post-ex	• Fatigue ↓ (p < .037) in both exercise conditions vs control conditions post-ex
Szabo 2003[46]	• No significant change (p > .05)	• PD ↓ ~11% (p < .001) post-ex vs pre-ex	• No significant change (p > .05)
Treasure & Newbery 1998[47]	Moderate Intensity group: • PA ↑ (~14%, 4%) (p < .01) post-ex vs pre-ex and during-ex respectively High Intensity group: • PA ↑ ~17% (p < .01) post-ex vs during-ex Moderate & High Intensity vs control: • PA ↑ ~36% (p < .05) post-ex in moderate intensity vs control • PA ↑ ~29% (p < .05) post-ex in high intensity vs control	• Not Measured	Moderate Intensity group: • Fatigue ↓ ~35% (p < .01) post-ex vs during-ex High Intensity group: • Fatigue ↑ ~63% (p <.01) post-ex vs pre-ex • Fatigue ↑ ~1.4 fold (p < .01) during-ex vs pre-ex • Fatigue ↓ ~31% (p < .01) post-ex vs during-ex Moderate vs High Intensity: • Fatigue ↑ ~98% (p < .05) in high intensity vs moderate intensity during-ex • Fatigue ↑ ~1.1 fold (p < .05) in high intensity vs moderate intensity post-ex
Van Landuyt et al. 2000[67]	• PA ↑ (p < .01) immediately post-ex vs pre-ex which continued until 20mins post-ex	• NA ↑ (p < .01) immediately & 10mins post-ex vs pre-ex	• Fatigue ↓ (p < .01) both immediately & 20mins post-ex vs pre-ex
Watt & Spinks 1997[49]	• PWB ↓ (p < .05) immediately post-ex vs pre-ex in exercise group Exercise vs. Non-Exercise groups: • PWB ↑ (p < .05) immediately post-ex in exercise group vs non-exercise groups • PWB ↑ (p < .05) 90mins post-ex in exercise group vs non-exercise groups	• PD ↓ (p < .05) 90mins post-ex in exercise groups vs non-exercise groups	• Fatigue ↑ (p < .05) immediately post-ex vs pre-ex • Fatigue ↓ (p < .05) 90mins post-ex in exercise groups vs non-exercise groups
RESISTANCE EXERCISE STUDIES			
Comstock et al. 2013[30]	• Not Measured	Post exercise vs pre exercise: • PD ↑ 1.6-fold (p < .05) in lean group immediately post-ex vs pre-ex, and ↑ 1.8-fold 24hrs post-ex • ↑ 3.4-fold (p < .05) in WHO 1 group immediately post-ex vs pre-ex • ↑ 3.5-fold (p <.05) in WHO 2/3 group immediately post-ex vs pre-ex, ↑ ~117% 24hrs post-ex	Post exercise vs pre exercise: • Fatigue ↑ 4.1-fold (p < .05) in lean group immediately post-ex vs pre-ex • ↑ 4-fold (p < .05) in WHO 1 group immediately post-ex vs pre-ex • ↑ 3.6-fold (p < .05) in WHO 2/3 group immediately post-ex vs pre-ex, ↑ 5.2-fold 24hrs post-ex

Table 3. (Continued)

STUDY	PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT	PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY	FATIGUE
Levinger et al. 2009[29]	Post exercise vs pre exercise: • PWB ↑ (p < .002) in all women post-ex vs pre-ex • No significant change (p > .05) in men	• No significant change (p > .05)	Post exercise vs pre exercise: • Fatigue ↑ ~29% (p < .029) in men post-ex vs pre-ex • No significant change (p > .05) in women
COMBINATION EXERCISE STUDY			
Maraki et al. 2005[56]	Post exercise vs pre exercise: • PA ↑ ~48% (p < .003) in morning-ex vs pre-ex, ↑ ~23% (p < .009) in evening-ex Control vs pre exercise: • PA ↑ 30% (p < .014) in morning session vs pre-session Control vs exercise: • PA ↑ 51% (p < .021) in morning post-ex vs morning control	Post exercise vs pre exercise: • NA ↓ 20% (p < .027) in morning-ex vs pre-ex • ↓ ~5% (p < .042) in morning control vs pre-session • No change (p > .05) in NA in evening-ex session	• Not Measured
COMPARATIVE EXERCISE STUDY			
McGowan et al. 1991[50]	• No significant change (p > .05)	• NA ↓ ~25% (p < .012) in all exercise groups combined post-ex vs control	• Fatigue ↑ ~74% (p < .017) in weight-lifting class post-ex vs pre-ex
Szabo et al. 1998[71]	• No significant change (p > .05)	Aerobic exercise vs control: • No significant change (p > .05) Anaerobic exercise vs control: • No significant change (p > .05)	Aerobic exercise vs control: • No significant changes (p > .05) Anaerobic exercise vs control: • No significant change (p > .05)

Abbreviations: during-ex, during exercise; evening-ex, evening exercise; HR_{max}, age-predicted heart rate maximum; HRR, heart rate reserve; morning-ex, morning exercise; NA, negative affect; PA, positive affect; PD, psychological distress; post-ex, post-exercise; pre-ex, pre-exercise; PWB, positive well-being; SA, state anxiety; VAMS, Visual Analog Mood Scale; WHO, World Health Organization.
↑ indicates increased and ↓ indicates decreased.

studies reported no significant change in perception of fatigue following aerobic exercise.[35,46,64,66,68]

Resistance exercise

Acute resistance exercise increased PWB by 3-fold in women but not in men in 1 study.[29] This study also reported that acute resistance exercise had no effect on PD,[29] whereas a second study reported an increased PD score immediately and 24 hours post-exercise (1.6- to 3.5-fold).[30]

Acute resistance exercise increased fatigue 4.1-fold in individuals within a healthy weight range and 5.2-fold in individuals who were obese (BMI $\geqslant$ 30 kg/m^2) both immediately and 24 hours post-exercise.[30] Following similar intensity, type, and duration of resistance exercise, men perceive more fatigue than women.[29]

Combination of exercise

A combination of aerobic and resistance exercise increased PWB (23%-48%) compared with baseline.[56] However, when aerobic exercise was compared with resistance exercise, there were no significant differences in PWB.[71] Another study also reported no significant changes in PWB.[50] A combination of aerobic and resistance exercise decreased PD by 20%.[56] Comparing aerobic exercise with resistance exercise yielded no significant changes in PD[71]; however, another aerobic and resistance comparative study reported PD to decrease 25% in all modes of exercise compared with control.[50] One study comparing aerobic and resistance exercise reported no significant changes in fatigue,[71] whereas another reported that only resistance exercise increases perception of fatigue (74%).[50]

Discussion

We report that acute aerobic exercise (a) improves PWB and has the potential to reduce PD in healthy weight individuals but may increase PD in obese individuals, whereas (b) the effects of aerobic and resistance exercise on the perception of fatigue are still unclear. It should also be acknowledged that 2 of the 42 studies reported a decrease in PWB after acute aerobic exercise. Each form of exercise may be beneficial, but with the current limited data, it remains unclear whether there is a difference between exercise modes.

Aerobic exercise

Positive well-being can be defined as the degree to which individuals are psychologically fully functioning or realizing their full potential.[72] It appears that the change (increase or decrease) in PWB following aerobic exercise depends on the individual's self-perceived efficacy. Those who have high self-efficacy prior to exercise are more likely to benefit with increases in PWB, but those with low in self-efficacy may feel less positive following exercise.[33,34] Changes in self-efficacy during exercise may be linked to PWB changes, as it was reported to increase post-exercise which was reflective of increases in PWB. These findings are similar to previous research investigating the effects of acute aerobic exercise on participants who are diagnosed with psychological disorders such as depression, schizophrenia, and anxiety.[18–21] These findings have implications for clinical exercise practice as it indicates that the individual's perception or feelings prior to exercise may determine to what degree they will enjoy the exercise and, in turn, affect long-term adherence to exercise. Furthermore, this should be taken into consideration when prescribing exercise to those with low self-efficacy to reduce the likelihood of dropout. Our review showed that acute aerobic exercise improves PWB in individuals who are within the healthy weight range. This finding has clinical importance as using non-pharmaceutical options could be an alternative approach to improve PWB in any population but may also be applied to those who are obese and those who live with psychological disorders. The exercise alternative may be an option for those who are reluctant to use medication.

Psychological distress is often described as a blanket term referring to feelings such as anxiety, depression, and stress-related emotions.[51] Those with both depressive and anxious distress symptoms have been shown to have an increased risk of developing CVD.[73] Aerobic exercise has the capacity to reduce PD in those with a healthy body weight but may increase in those who are obese. These findings are similar to research that has been conducted on acute exercise in those with psychological disorders including depression, anxiety, and schizophrenia.[19,21] This finding highlights that even a single bout of aerobic exercise could help in reducing PD and possibly affecting the chance of psychological complications arising. On the contrary, 5 studies found that PD had increased compared with baseline levels.[34,48,53,60,67] The different findings between the studies that reported reduced PD and increased PD following exercise can possibly be explained by the fact that participants who reported reduced PD had been physically active recently, whereas most of those who reported PD to increase had not been recently active, which may include individuals who are obese. Further studies should be conducted to determine whether this factor can affect the outcome of PD, and if not, then whether acute exercise is more likely to increase or decrease PD.

The definition of fatigue is still widely unclear in the research field as it currently has no known biological markers to be measured.[52] However, for the purpose of this review, fatigue was referred to as having feelings of a decreased capacity to complete both physical and mental activities.[74] The scales used for fatigue, such as the SEES and EFI, both have a subscale that observes fatigue or physical exhaustion.[51,75] Acute aerobic exercise decreased perceived fatigue in 10 studies we reviewed. One of these reported that fatigue was significantly reduced following exercise but only in individuals with high self-efficacy prior to exercise.[34] Similar to the results for PWB, it may indicate that self-efficacy is a key factor in helping improve psychological attributes in acute exercise. Clinically, if exercise is to reduce the perception of fatigue, it can be beneficial as it will allow individuals to maintain an active lifestyle. However, others reported that fatigue increased compared with baseline.[31,44,47,49,53,57,60,69] The difference in findings between studies who reported fatigue to increase and decrease could be explained by (a) some of the studies that reported an increase in fatigue used participants who were inactive recently and (b) large variations in exercise modes between each study. Along with these, it may be expected that fatigue will occur as a result of a single bout of exercise, where a chronic training program could help reduce fatigue over a longer period of time.[76] The time when fatigue levels are reported could also have an impact on the results. Further research using similar populations and equipment could provide more consistent results for the effect of acute aerobic exercise on fatigue.

Acute aerobic exercise has been shown to improve PWB; however, its effects on PD and perceived fatigue are variable. In circumstances where medication is contraindicated or proving to be ineffective, acute aerobic exercise could be used to complement or further improve treatment results. However, there is some evidence indicating that exercise may not be superior and warrants the need for further research in this area to clarify.[77] Acute aerobic exercise has also been shown to negatively affect PD and fatigue in some cases. Further research should be conducted to clarify the effect acute aerobic exercise has on these psychological attributes, especially PD and perceived fatigue.

Resistance exercise

To date, there are very limited data examining the effects of acute resistance exercise on psychological parameters. In women, but not men, PWB appears to increase following acute resistance exercise.[29] In contrast, perception of fatigue was higher in men than women. However, because only 1 study identified reported PWB, the effect of acute resistance exercise, including mode and intensity, is largely unknown. Resistance exercise may yield psychological benefits and may be a good complementary mode of exercise to aerobic exercise, especially in those who hold it as a higher preference. Further studies are needed to test this hypothesis.

The effect of acute resistance exercise on PD is not clear as there are only 2 studies with conflicting results in individuals who have a healthy weight and are obese.[29,30] As with PWB, the lack of studies reporting acute resistance exercise inhibits the capacity to compare it with acute aerobic exercise.

Resistance exercise increased fatigue in men,[29] whereas another study reported very large increases in fatigue in both men and women who are of normal weight and obese.[30] These findings were valuable to this review as they included both non-obese and obese individuals.

The effect acute resistance exercise had on PWB was positive, but unfortunately it was only measured in one of the 2 studies and only in women. Therefore, the positive effect may not be a true indicator of how acute resistance exercise affects PWB. The effect on PD and perceived fatigue was disputed, but as for PWB may not provide a clear insight as to the true effects acute resistance exercise produces due to the lack of literature.

Combination of exercise

The study that combined acute aerobic and resistance exercise reported that PWB had increased compared with baseline.[56] This finding is promising but not sufficient to make a definitive conclusion regarding the effect of combined exercise versus each type of exercise separately. Further research is required to determine which type of exercise provides superior results in changing PWB.

The effect of a combination of exercise on PD is unclear. The results of the 2 studies included were varied and reported change between different intervention groups. These results provide little insight as to which mode is superior, due to the lack of studies to compare with, just as in the combination exercise study. Further investigation into why these studies are not as common as aerobic or resistance exercise might also be beneficial to help determine the ideal mode of exercise to reduce PD.

The effect of a combination of exercise on fatigue is also still unclear. Only the comparative acute exercise studies reported fatigue, and these found that it had increased when comparing 2 different types of aerobic exercise, as well as after a bout of resistance exercise, but there was no difference between aerobic and resistance exercise.[50,71] This further outlines the lack of literature in this mode of exercise and requires further research to help gain more clarity when determining the better mode of exercise to help reduce fatigue.

A combination of acute aerobic and resistance exercise was reported to increase PWB but decrease PD only at a certain time point.[56] A comparative acute aerobic and resistance exercise study reported no change in PWB, increases in PD, and perceived fatigue between different types of aerobic exercise only.[71] The lack of literature using these 2 types of acute exercise inhibits the ability to confidently determine whether aerobic, resistance, or a combination of exercise is most beneficial; hence, no difference in exercise modes appears to exist. The individual's preference on mode of exercise could also have an impact on the outcome of the psychological responses, as well as differences in their performance compared with their personal expectations during the exercise. Further research would be appropriate to help understand which would be best to apply to achieve the best outcome for all patients.

A limitation of this study is the relative small number of studies that examined the effect of acute resistance and combined exercise on psychological parameters. Reporting results from a small amount of studies may not provide significant evidence to be used in practice, but is a first step towards clarifying future research needs. Most of the papers were classed as high risk for participant, personnel, and outcome assessor bias; however, it should be acknowledged that it is very difficult to blind in exercise studies. This review could be used as a stepping stone for future researchers to begin filling the gaps in literature. Six studies only used participants who are overweight/obese (BMI ≥ 25 kg/m^2), and only 2 of those used obese individuals (BMI ≥ 30 kg/m^2).[29,30] Nevertheless, we identified that current evidence indicates that acute aerobic exercise can lead to a higher perception of PWB in individuals free from psychological disorders. The evidence indicates variability regarding the effect of acute aerobic exercise on PD, providing indications for further research in this area. Individuals who are obese, and those with healthy weight, can exhibit psychological benefits from exercise from a single exercise session, and these positive benefits of exercise can be used by physical activity and health professionals as a tool to increase long-term participation in exercise in these populations. As low PWB and increased PD have been indicated as risk factors for CVD, acute exercise is important in the prevention of developing CVD.

We report that acute aerobic (a) improves PWB and also has the potential to reduce PD in normal weight individuals but may increase PD in obese individuals, and (b) the effects of aerobic and resistance exercise on the perception of fatigue, as well as which form of exercise yield superior psychological benefits, are currently unclear.

Author Contributions

Conceived and designed: TE, SC, ARN, IL. Analyzed the data: TE, SC, IL. Wrote the first draft of the manuscript: TE. Contributed to the writing of the manuscript: All authors. Agree with manuscript results and conclusions: All authors. Jointly developed the structure and arguments for the paper: All authors. Made critical revisions and approved final version: All authors.

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