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/m²). 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

[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/m²), 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/m²).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.¹⁴¹⁵

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.¹⁶¹⁷ Exercise may also be

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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/m², 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/m². Only 6 studies included participants with a mean BMI in the overweight or obese classification.29–32,57,59 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<sup>54</sup> | ✓                             | ✓                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Blanchard et al. 2001<sup>56</sup> | ✓                             | ✓                      | ✓                                                          | ✓                                | ✓                                  | ✓                              |
| Blanchard et al. 2002<sup>58</sup> | ✓                             | ✓                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Blanchard et al. 2004<sup>51</sup> | ✓                             | ✓                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Boutcher et al. 1997<sup>55</sup> | N/A                           | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Bozoian et al. 1994<sup>53</sup> | ✗                             | ✗                      | ✓                                                          | ✓                                | ✓                                  | ✓                              |
| Cox et al. 2001<sup>59</sup> | ✓                             | ?                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Daley & Huffen 2003<sup>57</sup> | ?                             | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Daley & Maynard 2003<sup>62</sup> | ?                             | ?                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Daley & Welch 2003<sup>68</sup> | ?                             | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Daley & Welch 2004<sup>32</sup> | ?                             | ?                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Dunn & McAuley 2000<sup>37</sup> | ✓                             | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Ekkekakis et al. 2000<sup>28</sup> | Protocol 1 (Study III)        | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
|                             | Protocol 2 (Study IV)         | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Ewing et al. 1984<sup>63</sup> | N/A                           | ✓                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Focht & Hausenblas 2001<sup>54</sup> | ✓                             | ✗                      | ✓                                                          | ✓                                | ✓                                  | ✓                              |
| Focht et al. 2007<sup>31</sup> | N/A                           | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Gauvin et al. 1997<sup>59</sup> | ✓                             | ✓                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Hansen 2001<sup>38</sup> | ✓                             | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Koltyn et al. 1998<sup>69</sup> | ?                             | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Lochbaum 2004<sup>58</sup> | ✓                             | ✗                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| McAuley, 1999<sup>34</sup> | N/A                           | ✓                      | ✓                                                          | ✓                                | ✓                                  | ✓                              |
| Nabetani & Tokunaga 2001<sup>41</sup> | ✓                             | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Parfitt et al. 2000<sup>40</sup> | N/A                           | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Parfitt & Gledhill 2004<sup>53</sup> | ✓                             | N/A                    | ✓                                                          | ✓                                | ✓                                  | ✓                              |
| Petruzzello & Landers 1994<sup>42</sup> | ✓                             | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Petruzzello et al. 1997<sup>43</sup> | N/A                           | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Petruzzello & Tate 1997<sup>48</sup> | ✓                             | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Plante et al. 2001<sup>44</sup> | N/A                           | ✓                      | ✗                                                          | ✓                                | ✓                                  | ✓                              |
| Plante et al. 2007<sup>70</sup> | Protocol 1                     | N/A                    | ✗                                                          | ✓                                | ✓                                  | ✓                              |
|                             | Protocol 2                     | N/A                    | ✓                                                          | ✓                                | ✓                                  | ✓                              |
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 and 75 minutes, at intensities varying from 50% to 85% peak heart rate (HRpeak), 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 seconds29,30 (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-down56 (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),29,32,34,35,37,40,45,48,49,53,57,59,60,68,70 and 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 fatigue28–31,33–37,39,40,42–45,47,48,55,56,64,65,67,69–71 (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

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**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 199565         | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| Roth 198966                  | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| Rudolph & Butki 200845       | N/A                         | ?                      |                                                            |                                   |                                    |                                |
| Spence & Blanchard 200145    | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| Szabo 200346                 | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| Treasure & Newbery 199847    | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| Van Landuyt et al. 200067    | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| Watt & Spinks 199749         | ✓                           | ✓                      |                                                            |                                   |                                    |                                |
| Comstock et al. 201350       | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| Levinger et al. 200929       | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| Moraki et al. 200548         | N/A                         | ✓                      |                                                            |                                   |                                    |                                |
| McGowan 199150              | ?                            | ?                      |                                                            |                                   |                                    |                                |
| Szabo et al. 199871          | ?                            | ?                      |                                                            |                                   |                                    |                                |

✓ 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.
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
| Referenece | Study Design | Number of Participants | Participant Characteristics | Participant Inclusion and Exclusion Criteria | Exercise Protocol | Psychological Measures Investigated | Psychological Measure Time Points |
|------------|--------------|------------------------|-----------------------------|-----------------------------------------------|-------------------|-------------------------------------|----------------------------------|
| Bixby et al. 2015 | 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 | Pre-exercise (baseline), 10, 20, 30mins during-ex and recovery (VAMS), 20mins during-ex & recovery (PANAS) |
| Blanchard et al. 2001 | Randomized crossover study | n = 24 | Highly Fit Age: 23.4 ± 4.7 BMI*: 21.8 (SD not reported) Unfit Age: 24.8 ± 7.7 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 | Randomized controlled study | n = 60 | 15min, 50% HRR: Age: 22.33 ± 8.5 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 | 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 |
| Boucher et al. 1997 | 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 | Pre-exercise (baseline), 5 & 10mins into each condition, 5 & 10mins post-ex |
Table 2. (Continued)

| REFERENCE STUDY DESIGN | PARTICIPANT CHARACTERISTICS | PARTICIPANT INCLUSION AND EXCLUSION CRITERIA | EXERCISE PROTOCOL | PSYCHOLOGICAL MEASURES INVESTIGATED | PSYCHOLOGICAL MEASURE TIME POINTS |
|------------------------|-----------------------------|---------------------------------------------|-------------------|-------------------------------------|----------------------------------|
| Bozoian et al. 1994 | 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 | - 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 | Age: 28.3 ± 8.3 BMI: N/R | Inclusion - History of engaging in ≥ 3 exercise sessions of vigorous intensity for 30-60mins | - 30mins running treadmill or stepper at either 50% or 75% predicted VO₂max | - SEES | Pre-exercise (baseline) and 5, 10mins post-ex |
| Daley & Huffen 2003 | 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 | - 20mins on cycle ergometer at 40% or 70% HRmax | - SEES | Pre-exercise (baseline), 10mins during-ex and 5mins post-ex |
| Daley & Maynard 2003 | 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) | - 30mins at 70-85% age-adjusted HRmax using preferred exercise mode, or 30mins at 70-85% HRmax cycle ergometer | - PANAS | Pre-exercise (baseline), 15mins during-ex, 5mins post-ex |
| Daley & Welch 2003 | Active Group: Age: 20.1 ± 1.6 Mass: 68.6 ± 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 | - Treadmill running at 50-55% and 80-85% VO₂max, for 20mins | - SEES | Pre-exercise (baseline), 10mins during-ex, 5mins post-ex |

(Continued)
| Reference                  | Study Design                     | Number of Participants | Participant Characteristics | Participant Inclusion and Exclusion Criteria | Exercise Protocol | Psychological Measures Investigated | Psychological Measure Time Points |
|----------------------------|----------------------------------|------------------------|-----------------------------|---------------------------------------------|-------------------|-------------------------------------|----------------------------------|
| Daley & Welch 2004<sup>42</sup> | Case controlled study             | n = 23                 | Male:                       | Inclusion - Recreationally active ≥ 30mins, ≥ 3 times per week, ≥ 6 months | - 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 |
|                            |                                  |                        | Age: 23.5 ± 0.5 BMI: 26.60 (SD not reported) | Exclusion - N/R                     |                   |                                    |                                  |
|                            |                                  |                        | Female:                     |                                             |                   |                                    |                                  |
|                            |                                  |                        | Age: 21.4 ± 1.0 BMI: 25.42 (SD not reported) |                                             |                   |                                    |                                  |
| Dunn & McAuley 2000<sup>37</sup> | 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. | - 20mins walking or jogging on treadmill (based on target HR) at 60% VO<sub>2peak</sub>, - 20mins walking or jogging at 80% VO<sub>2peak</sub> | - SEES, EFI, CS | Pre-exercise (baseline), 10mins during-ex, immediately post-ex, 20mins post-ex |
|                            |                                  |                        |                             | Exclusion - N/R                     |                   |                                    |                                  |
| Ekkekakis et al. 2000<sup>18</sup> | Protocol 1 Case-control study    | n = 69                 | Protocol 1 (Study III) Age: 22.0 (SD not reported) BMI: N/R | Inclusion - Undergraduate students | - 15mins treadmill walking where mean RPE: 9.9 ± 1.9 | - FS, FAS, SAM-A, SAM-V, AG-A, AD ACL | Pre-exercise (baseline), 8, 15mins during-ex, immediately post-ex, 10mins post-ex |
|                            | Protocol 2 Case-control study    | n = 42                 | Protocol 2 (Study IV) Age: 20.0 (SD not reported) BMI: N/R | Inclusion - Undergraduate students | - 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 |
|                            |                                  |                        |                             | Exclusion - N/R                     |                   |                                    |                                  |
| Ewing et al. 1984<sup>63</sup>   | Case-controlled study            | n = 52                 | Age: 22.4 ± 4.4 BMI: N/R | Inclusion - At least high school education | - 5mins of treadmill jogging at 65-70% HR<sub>max</sub> | - POMS                           | - Pre-exercise (baseline), immediately post-ex & 1.5hrs post-ex |
| Focht & Hausenblas 2001<sup>64</sup>  | 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 | - 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<sup>71</sup>    | Case control study               | n = 18 (Young) n = 15 (Older) | Young Group: Age: 24.1 ± 3.4 BMI: 26.1 ± 3.8 | Inclusion - Sedentary (< 2 x 20 min bouts of structured exercise within the last 6 months) | - Graded VO<sub>2peak</sub>, Cycle ergometer, - 20min stationary cycling at 65% VO<sub>2peak</sub> | - FS, FAS, EFI | Pre-exercise (baseline), 10mins during-ex, and immediately post-ex |
|                            |                                  |                        | Older Group: Age 64.2 ± 6.5 BMI: 25.9 ± 2.8 | Exclusion - N/R                     |                   |                                    |                                  |
| Reference Study Design       | Number of Participants | Participant Characteristics | Participant Inclusion and Exclusion Criteria | Exercise Protocol | Psychological Measures Investigated | Psychological Measure Time Points |
|------------------------------|------------------------|----------------------------|----------------------------------------------|-------------------|-------------------------------------|----------------------------------|
| Gauvin et al. 1997 \(39\)    | n = 72                 | Male: Age: 35.70 ± 6.39    | **Inclusion** - English speaking individuals between 25-40 yrs old - Individuals reporting ≤ 1 bout of vigorous exercise in past month  | - 30 min cycle ergometer at either 30%, 50% or 70% HRR | - EFI - FS                        | Pre-exercise (baseline), 10 mins post-ex |
|                              |                        | Female: Age: 37.73 ± 5.66  | **Exclusion** - Those at risk of cardiovascular or orthopaedic complications arising from vigorous exercise |                   |                                     |                                  |
|                              |                        | Body fat %: 16.14 ± .71 (SE) |                                              |                   |                                     |                                  |
|                              |                        | Body fat %: 21.54 ± .73 (SE) |                                              |                   |                                     |                                  |
| Hansen et al. 2001 \(38\)    | n = 14                 | Age: 20-26 (SD not reported) | **Inclusion** - Female college students | - Cycle ergometer at 60% \(\text{VO}_{2\text{max}}\) for either 10, 20 or 30 mins | - POMS                             | Pre-exercise (baseline), 10 mins post-ex |
|                              |                        | BMI: N/R                    | **Exclusion** - Males - Individuals with contraindications to aerobic exercise |                   |                                     |                                  |
| Koltyn, et al. 1998 \(60\)   | n = 16                 | Age: 23.0 ± 3.0            | **Inclusion** - Male | - Incremental Tests: Cycle ergometer until participants couldn’t maintain 75 RPM for 3 sec, increasing Watts each 2 mins - Power Tests: Cycle ergometer at peak power (W) participants had maintained in previous test | - STAI - POMS                      | Pre-exercise, (baseline), 15 mins post-ex |
|                              |                        | BMI*: 23.36 (SD not reported) | **Exclusion** - N/R |                                              |                                     |                                  |
| Lochbaum et al. 2004 \(58\)  | n = 53                 | Active: Age: 24.35 ± 3.54  | **Inclusion** - Active participants engaged in exercise ≥ 3 times per week, 45 mins over past 6 months - Inactive participants required to have no cardiovascular or other fitness training in past 6 months | - 30 min treadmill run at either 50-55% \(\text{VO}_{2\text{max}}\) or 70-75% \(\text{VO}_{2\text{max}}\) | - AD ACL                           | Pre-exercise (baseline), 5, 15 & 25 mins during-ex, 10 & 20 mins post-ex |
|                              |                        | BMI*: 22.89 (SD not reported) | **Exclusion** - N/R |                                              |                                     |                                  |
|                              |                        | Inactive: Age: 23.35 ± 3.84 |                                              |                   |                                     |                                  |
|                              |                        | BMI*: 26.53 (SD not reported) |                                              |                   |                                     |                                  |
| McAuley et al. 1999 \(34\)   | n = 46                 | Age: 20.4 ± 2.8            | **Inclusion** - Low to moderately active women where reporting to be sedentary or exercising <3 times per week qualifies - College women | - 20 mins Stairmaster exercise machine at moderate-hard intensity RPE scale 12-16 | - CS - FS - SEES                   | Baseline, immediately post-manipulation, pre-exercise, 10 mins during-ex, and immediately and 15 mins post-ex |
|                              |                        | High Efficacy BMI: 23.6 ± 4.4 | **Exclusion** - N/R |                                              |                                     |                                  |
|                              |                        | Low Efficacy BMI: 22.3 ± 2.7 |                                              |                   |                                     |                                  |
| REFERENCE STUDY DESIGN NUMBER OF PARTICIPANTS | PARTICIPANT CHARACTERISTICS | PARTICIPANT INCLUSION AND EXCLUSION CRITERIA | EXERCISE PROTOCOL | PSYCHOLOGICAL MEASURES INVESTIGATED | PSYCHOLOGICAL MEASURE TIME POINTS |
|---------------------------------------------|----------------------------|-----------------------------------------------|-------------------|--------------------------------------|----------------------------------|
| Nabetani & Tokunaga 200141 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. 200046 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% VO2max - 20mins treadmill running at self-selected intensity | SEES IMI | Pre-exercise (baseline), 5, 10, 15 & 20mins during-ex, 5mins post-ex |
| Parfitt & Gledhill 200453 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% HRmax, 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 199442 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% VO2max | SAI PANAS | Pre-exercise (baseline), immediately, 5, 10, 20 & 30mins post-ex |
| Petruzzello et al. 199743 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 199748 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% VO2max and 75% VO2max | AD ACL SAI | Pre-exercise (baseline), 5, 15 & 25mins during-ex, immediately, 5, 10, 20 & 30mins post-ex |
| Plante et al. 200144 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% HRmax, either with or without being able to talk to another person | AD ACL M-C SDS | Pre-exercise (baseline), immediately post-ex |
| REFERENCE STUDY DESIGN | NUMBER OF PARTICIPANTS | PARTICIPANT CHARACTERISTICS | PARTICIPANT INCLUSION AND EXCLUSION CRITERIA | EXERCISE PROTOCOL | PSYCHOLOGICAL MEASURES INVESTIGATED | PSYCHOLOGICAL MEASURE TIME POINTS |
|------------------------|------------------------|-----------------------------|---------------------------------------------|-------------------|------------------------------------|---------------------------------|
| Plante et al. 200770    | Protocol 1:            |                             | Inclusion                                   |                   |                                    |                                 |
|                        | Case-controlled study  | Age: 18.54 ± 1.02           | - Female                                    | - 20mins cycle ergometer at 60-70% HR<sub>max</sub> alone, with stranger or with close friend | - M-C SDS - AD ACL - PACES      | Pre-exercise (baseline), immediately post-ex |
|                        | Case-controlled study  | BMI: N/R                    | - Undergraduate university students         |                   |                                    |                                 |
|                        | n = 128                |                             | Exclusion                                   |                   |                                    |                                 |
|                        | Protocol 2:            | Age: 19.31 ± 0.94           | - Female                                    | - 20mins either walking on treadmill with or without friend, or walking around university campus with or without friend, all at 60-70% HR<sub>max</sub> | - AD ACL - PACES                | Pre-exercise (baseline), immediately post-ex |
|                        | Case-controlled study  | BMI: N/R                    | - Undergraduate university students         |                   |                                    |                                 |
|                        | n = 88                 |                             | Exclusion                                   |                   |                                    |                                 |
| Rejeski et al. 199565   | Case control study     | Age: 18.3 ± 0.1             | Inclusion                                   |                   |                                    |                                 |
|                        | n = 80                 | Body fat %: 25.90 ± 0.45    | - Moderately fit                             | - 10, 25 or 40mins of cycle ergometer at 70% HR<sub>R</sub> | - PANAS - EFI - FS              | Pre-exercise (baseline), 20mins post-ex |
| Roth 198966            | Case controlled study  | Age: 20.8 ± 3.5             | Inclusion                                   |                   |                                    |                                 |
|                        | n = 80                 | BMI: N/R                    | - University students                       | - 20mins cycle ergometer at HR between 115 – 135bpm         | - POMS                          | Pre-exercise (baseline), 15mins post-ex |
| Rudolph & Burki 200855  | Randomized controlled trial | 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 | - 10, 15 or 20mins treadmill running at RPE 13 | - EES - SEES | Pre-exercise (baseline), 5 and 20mins post-ex |
| Spence & Blanchard 200165 | Randomized control case study | 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 Exclusion | - 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 | Age: 20.3 ± 2.4 BMI*: 23.68 (SD not reported) | Inclusion | - Female university students Exclusion | - Treadmill run/jogging at self-selected intensity for 20mins | - POMS | Pre-exercise (baseline), 5mins post-ex |
| REFERENCE                  | STUDY DESIGN          | NUMBER OF PARTICIPANTS | 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    | Randomized case control study | n = 60                | Male:              | Age: 23.17 ± 10.5     | Inclusion - Sedentary, no regular exercise in the past 6 months - Undergraduate students | - 15mins cycle ergometer at either 45-50% HRR or 70-75% HRR | - EFS | Pre-exercise (baseline), immediately & 15mins post-ex |
|                            |                        |                       | Female:             | Mass: 190.7lbs        | - N/R                                        |                  |                                   |                                  |
|                            |                        |                       |                    | Age: 22.5 ± 4.7       |                                             |                  |                                   |                                  |
|                            |                        |                       |                    | Mass: 146.4lbs        |                                             |                  |                                   |                                  |
| Van Landuyt 2001           | Case control study     | n = 82                | Male:              | Age: 19.9 ± 1.4       | Inclusion - University students              | - 30mins cycle ergometer at 60% VO² max | - FSA | Pre-exercise (baseline), 7, 12, 17, 22 & 27mins during-ex, immediately, 10 & 20mins post-ex |
|                            |                        |                       | Female:             | BMI*: 23.31 (SD not reported) | - N/R                                        |                  |                                   |                                  |
| Watt & Spinks 1997         | Randomised-cross over study | n = 28               | Male:              | Age: 33.93 ± 9.12     | Inclusion - Habitual exercisers: ≥ 3 session per week, ≥ 20mins aerobic exercise - Sedentary: <3 exercise sessions per week | - 20mins cycle ergometer at 60% VO² max | - SEES | Pre-exercise (baseline), immediately post-ex & 90mins post-ex |
|                            |                        |                       | Female:             | BMI*: 22.53 (SD not reported) | - N/R                                        |                  |                                   |                                  |
|                            |                        |                       |                    |                       |                                             |                  |                                   |                                  |
| RESISTANCE EXERCISE STUDIES|                        |                       |                    |                       |                                             |                  |                                   |                                  |
| Comstock et al. 2013       | Between-subject design | n = 19                | Lean Group:        | Age: 20.1 ± 2.1       | 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) | - BMI classed as lean, WHO 1 or WHO 2/3 | - 10cm line Likert “Pain and Soreness” scale | Pre-exercise (baseline), immediately and 24hr post-ex |
|                            |                        |                       | WHO 1 Group:       | BMI: 22.8 ± 1.4       | - Any cardiovascular, endocrine, metabolic disease, other acute or chronic disease - Using medications or dietary supplements - Smoker - Lost ≥3 kg at any time 3 months pre-study | - 85-95% 1RM, 3 sets of 10 repetitions | - 10-point Likert “Fatigue” scale |                                  |
|                            |                        |                       | Age: 21.6 ± 2.5    | BMI: 32.3 ± 1.6       | - Completed resistance training for at least 6 months or any structured training regimen for 30mins, >2 per week | - Free weight resistance exercises | - 10-point Likert “General Soreness” scale |                                  |
|                            |                        |                       | WHO 2/3 Group:     | Age: 20.0 ± 1.4       |                                             |                  |                                   |                                  |
|                            |                        |                       | BMI: 39.4 ± 2.8    |                                             |                                             |                  |                                   |                                  |
| Levinger et al. 2009       | Cross sectional study  | n = 45                | Male BMI:          | Age: 51.4 ± 1.7       | Inclusion - People with obesity (waist circumference ≥ 94 cm for men, 80 cm for women) | - 45-50mins resistance exercise (2-3 sets at ~59% 1RM, 10 repetitions) | - SEES | 3-5mins pre-exercise (baseline) and immediately post-ex |
|                            |                        |                       | Female BMI:        | BMI: 29.1 ± 1.0       |                                             |                  |                                   |                                  |
|                            |                        |                       |                    | BMI: 26.7 ± 1.2       |                                             |                  |                                   |                                  |
| Reference Study Design | Participant Characteristics | Participant Inclusion and Exclusion Criteria | Exercise Protocol | Psychological Measures Investigated | Psychological Measure Time Points |
|------------------------|-----------------------------|---------------------------------------------|-------------------|-----------------------------------|----------------------------------|
| Elkington et al. 2020   | Age: 33.3 ± 8.4 BMI*: 22.8 (SD not reported) | Inclusion: Habitual Exercisers | - 60-75mins either anaerobic exercise (body-building) or aerobic (dance) exercise, martial arts, tai-chi/yoga or control | - EFI | 5mins pre-exercise (baseline), 5mins and 3hr post-ex |
| Mcgowan et al. 1991     | Age: N/R (college students) BMI: N/R | Inclusion: College students | - 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       | Age: 28.0 ± 6.4 BMI: 21.3 ± 1.6 | Inclusion: Healthy Female Aged 18-45 years BMI between 19-25 kg·m² | - 10mins warm-up, 20mins aerobic exercise, 20mins resistance exercise, 10mins cool-down | - PANAS | Pre-exercise (baseline) and post-ex |
| Maraki et al. 2005      | Age: 28.0 ± 6.4 BMI: 21.3 ± 1.6 | Inclusion: Healthy Female Aged 18-45 years BMI between 19-25 kg·m² | - Final set at ~81% 1RM 60-90sec rest between sets 90-120sec rest between exercises | - | |

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; HRmax, 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; VO₂max, maximum pulmonary oxygen uptake; VO₂peak, 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[^1^]         | Low intensity condition:                  | Low intensity condition:                               | Not Measured |
|                                | • VAMS score significantly ↑ (p < .05) at 20 & 30 mins into exercise & post-ex vs baseline | • NA scores significantly ↓ (p < .05) during & post-ex vs baseline |         |
|                                | High intensity condition:                 |                                                        |         |
|                                | • VAMS score significantly ↓ (p < .05) during-ex & post-ex vs baseline | • NA scores did not change significantly (p > .05) during-ex vs baseline |         |
|                                | • PA significantly ↑ (p < .01) during-ex compared to pre-ex in both intensities | • NA scores significantly ↓ (p < .05) post-ex vs baseline |         |
| Blanchard et al. 2001[^2^][^3^] | 50% HRR vs 80% HRR:                       | Post exercise vs pre exercise:                         | Exercise vs control: |
|                                | • PWB ↑ (p < .01) in 50% HRR intensity protocol vs 80% HRR protocol, participant group not indicated | • PD ↑ ~37% (p < .05) in 80% HRR intensity condition for unfit group vs pre-ex | 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%) |
|                                | Pre-ex vs post-ex:                        | • No significant change (p > .05) for any other condition in either classification vs pre-ex |         |
|                                | • PWB ↑ (p < .01) post-ex vs pre-ex in all conditions | • Fatigue ↓ ~36% (p < .05) post-ex vs pre-ex in 50% intensity condition |         |
|                                | Changes included:                        | • No significant change (p = .10) vs control           |         |
|                                | • 50% HRR = ↑ 17% fit group, ↓ 6% unfit group | • Fatigue ↓ ~2% (p < .05) post-ex vs pre-ex in 85% intensity condition |         |
|                                | • 80% HRR = ↑ 13% fit group, ↓ 2% unfit group | • No significant change (p > .05) from pre to post-ex vs control |         |
|                                | • Control = ↑ 14% fit group, 5% unfit group | • Fatigue ↓ ~26% (p < .05) from pre to post-ex vs control |         |
| Blanchard et al. 2002[^4^][^5^] | PA ↑ ~31% (p < .05) post-ex vs pre-ex in both 50 & 85% intensities | • Not Measured                                         |         |
| Blanchard et al. 2004[^6^]     | 25 min running condition:                | • Not Measured                                         |         |
|                                | • PA ↑ 67% (p < .05) post-ex vs control   | 25 min running condition:                              |         |
|                                | 40 min running condition:                | • No significant change (p = .10) vs control           |         |
|                                | • PA did not change significantly (p > .05) vs control | • Fatigue ↓ ~26% (p < .05) from pre to post-ex vs control |         |
| Boucher et al. 1997[^7^][^8^]   | Trained group:                           | Trained group:                                         |         |
|                                | • PA ↑ (p < .001) in both medium & high intensity during-ex vs pre-ex | • NA did not change (p > .05) during & post-ex vs pre-ex | Not Measured |
|                                | • PA did not change (p > .05) between trained and untrained post-ex | Untrained group:                                       |         |
|                                | Untrained group:                         | • NA ↓ (p < .01) during & post-ex vs pre-ex            |         |
|                                | • PA ↓ (p < .05) at 5 & 10 mins post-ex vs pre-ex | • High-efficacy group:                                 |         |
| Bozoian et al. 1994[^9^]       | High-efficacy group:                     | • Not Measured                                         |         |
|                                | • PWB ↑ 34% (p < .05) post-ex vs pre-ex   | High-efficacy group:                                   |         |
|                                | Low-efficacy group:                      | • Fatigue ↓ ~24% (p < .01) post-ex vs pre-ex           |         |
|                                | • PWB ↓ 34% (p < .05) post-ex vs pre-ex   | Low-efficacy group:                                    |         |

[^1^]: Bixby et al. 2001[^1^][^1^][^1^][^1^]
[^2^]: Blanchard et al. 2001[^2^][^3^]
[^3^]: 50% HRR vs 80% HRR:
[^4^]: Blanchard et al. 2002[^4^][^5^]
[^5^]: PA ↑ ~31% (p < .05) post-ex vs pre-ex in both 50 & 85% intensities
[^6^]: Blanchard et al. 2004[^6^]
[^7^]: 25 min running condition:
[^8^]: 25 min running condition:
[^9^]: Bozoian et al. 1994[^9^]
### Table 3. (Continued)

| Study                              | Psychological Well-Being / Positive Effect | Psychological Distress / Negative Affect / State Anxiety | Fatigue                          |
|------------------------------------|-------------------------------------------|--------------------------------------------------------|----------------------------------|
| Elkington et al. 2001              | Post exercise vs pre exercise:            | Post exercise vs pre exercise:                         | Post exercise vs pre exercise:   |
|                                   | • PWB ↑ 9% (p = .04) between 5mins and 60min post-ex vs pre-ex | • PD ↓ -22% (p = .04) at 5min post-ex vs pre-ex     | • Fatigue ↓ -21% (p = .007) at 60mins post-ex vs pre-ex |
|                                   | • ↑ 10% (p = .02) at 60mins post-ex vs pre-ex | • ↓ 29% (p = .005) at 30min post-ex vs pre-ex         | • No change between pre-ex and 5mins post-ex (p = .73) |
|                                   | • No change between exercise modes (η²p=0.003). | • PD ↓ -35% (p = .001) at 60min post-ex vs pre-ex   | • No change between pre-ex and 30mins post-ex (p = .33) |
|                                   |                                            | • No change between modes (η²p=0.001)                | Change in ex modes:              |
|                                   |                                            |                                                       | • Fatigue ↑ 27% (p < .025) on stepper vs treadmill |
| Daley & Huffen 2003               | PWB ↑ -18% (p < .05) post-ex vs during-ex in 70% HR_{max} condition | No significant changes (p > .05)                       | Fatigue ↑ (p < .01) post-ex and during-ex vs pre-ex in 70% HR_{max} condition |
|                                   | PA ↑ (-4%, -1%) (p = .01) post-ex in choice of exercise and control vs no choice cycle ergometry condition |                                           |                                 |
| Daley & Maynard 2003             | Low Intensity vs High Intensity Groups:   | 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 | Not Measured |
|                                   | • PWB ↑ -19% (p < .01) during-ex in low intensity group vs. high intensity group | PD ↓ -34% (p < .01) post-ex vs pre-ex               |                                      |
|                                   | • High Intensity Group:                   | PD ↓ -16% (p < .01) post-ex vs during-ex             |                                      |
|                                   | • PWB ↑ -30% (p < .01) post-ex vs pre-ex  |                                          |                                      |
|                                   | • PWB ↑ -26% (p < .01) post-ex vs during-ex |                                             |                                      |
| Daley & Welch 2004               | PWB ↓ -15% (p < .01) during-ex vs 5mins post-ex | PD did not change (p > .05) during-ex vs pre-ex | Fatigue ↓ (21% & 16%) (p < .01) 30mins & 1hr post-ex vs 5mins post-ex |
|                                   | PWB ↑ -23% (p < .01) 2hrs post-ex vs pre-ex | PD ↓ (24%) (p < .01) 5mins post-ex vs during-ex | Fatigue ↓ -33% (p < .01) 2hrs post-ex vs baseline |
|                                   |                                            | PD ↓ (32%) (p < .01) 2hrs post-ex vs baseline      | Fatigue did not change (p > .05) between 5min, 30min, 1hr and 2hrs post-ex |
| Dunn & McAuley 2000              | PWB ↑ -15% (p < .001) 20mins post-ex vigorous condition vs pre-ex | PD did not change (p > .05) between 5min, 30min, 1hr and 2hrs post-ex | Fatigue ↓ (-24%, 21% & 27%) (p < .001) during, immediately post & 20mins moderate condition post-ex 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 |                                            |                                      |
|                                   |                                            |                                            | Fatigue ↓ (33%, 33% & 42%) (p < .001) during, immediately post-ex & 20mins moderate condition post-ex vs pre-ex |

(Continued)
| STUDY                        | PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT | PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY | FATIGUE                        |
|-----------------------------|--------------------------------------------|----------------------------------------------------------|--------------------------------|
| Ekkekakis et al. 2000[18]   | Protocol 1 (Study III)                      | • NA ↑ (p < .001) immediately post-ex vs pre-ex          | • Not Measured                  |
|                            | • PA ↑ (p < .001) immediately post-ex vs pre-ex | • NA ↓ (p < .001) 15min post-ex vs pre-ex                |                                 |
|                            | • SAM-V & AG-V Valence did not change significantly (p > .05) | |                                 |
| Ewing et al. 1984[63]       | Protocol 2 (Study IV)                       | • NA ↑ (p < .001) immediately post-ex vs pre-ex          | • Not Measured                  |
|                            | • PA ↑ (p < .001) immediately post-ex vs pre-ex | • NA ↓ (p < .001) 15min post-ex vs pre-ex                |                                 |
|                            | • PA ↓ (p < .001) 15mins post-ex vs immediately post-ex | • NA ↓ (p < .001) 15min post-ex vs pre-ex                |                                 |
| Focht & Hausenblas 2001[64] | • PA ↑ −5% (p < .05) 1.5hrs post-ex vs pre-ex | • NA ↓ −39% (p < .0005) 1.5hrs post-ex vs immediately post-ex | • No significant changes (p > .05) |
| Focht et al. 2007[31]       | • No change (p < .57) (↑−7% younger group, ↓−10% older group) | • NA ↓ −18% (p < .001) 30mins post-ex vs pre-ex          | • Not Measured                  |
| Gauvin et al. 1997[39]      | • PA ↑ (p < .05) immediately post-ex vs pre-ex | • SA ↓ −18% (p < .001) 30mins post-ex vs pre-ex          |                                 |
| Hansen et al 2001[38]       | • PA ↑ (p < .014) at post-ex vs pre-ex      | • NA ↓ (p < .007) at 10min during-ex vs pre-ex           |                                 |
|                            | • PA ↑ (p < .01) at 10min during-ex vs pre-ex | • Fatigue ↑ −27% (p < .01) in young adults post-ex vs pre-ex |                                 |
|                            | • 30% HRR:                                  | • Fatigue ↑ −81% (p < .01) in older adults post-ex vs pre-ex |                                 |
|                            | • No significant changes in low intensity group (p > .05) | • Fatigue ↑ −32% & 34% (p < .001) 5mins post-ex vs pre-ex & control |                                 |
|                            | • 50% HRR:                                  | • PA ↑ −21% (p < .001) 30mins post-ex vs pre-ex & control |                                 |
|                            | • 70% HRR:                                  | • SA ↓ −18% (p < .001) 30mins post-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[48]    | • PA ↑ (p < .05) post-ex vs during & pre-ex | • 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                  |
| STUDY | PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT | PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY | FATIGUE |
|-------|--------------------------------------------|--------------------------------------------------------|---------|
| McAuley et al. 1999 | 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 | 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 | 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 | 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 | 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 | PA ↓ (p < .01) post-ex & during-ex vs pre-ex for non-active group  
PA did not change (p > .05) between exercising alone & exercising with another | 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 |
| Rejeski et al. 1995 | 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 | NA ↑ (p < .05) immediately post-ex vs pre-ex | Not Measured |

Table 3. (Continued)
| STUDY                        | PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT | PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY | FATIGUE                                      |
|-----------------------------|-------------------------------------------|----------------------------------------------------------|----------------------------------------------|
| Roth 198966                 | • 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       | Post exercise vs pre exercise:            | Post exercise vs pre exercise:                           |                                              |
|                             | • PWB ↑ ~9% (p < .05) at 20mins post-ex vs pre-ex in all conditions | • PD ↓ ~23% (p < .05) from pre-ex to 20mins post-ex in all conditions | • No significant changes (p > .05)           |
| Spence & Blanchard 2001     | • PWB ↑ (p < .01) 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 200346                | • No significant change (p > .05)          | • PD ↓ ~11% (p < .001) post-ex vs pre-ex                  | • No significant change (p > .05)            |
| Treasure & Newbery 1998     | Moderate Intensity group:                 | • Not Measured                                           |                                              |
|                             | • PA ↑ (~14%, 4%) (p < .01) post-ex vs pre-ex and during-ex respectively | Moderate Intensity group:                                 |                                              |
|                             | 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 | |                                              |
| Van Landuyt et al. 2000     | • 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          | • PWB ↓ (p < .05) immediately post-ex vs pre-ex in exercise group | • PD ↓ (p < .05) 90mins post-ex in exercise groups vs non-exercise groups | Fatigue ↑ (p < .05) immediately post-ex vs pre-ex |
|                             | Exercise vs. Non-Exercise groups:         | • Fatigue ↑ (p < .05) 90mins post-ex in exercise groups vs non-exercise groups | Fatigue ↑ (p < .05) 90mins post-ex in exercise groups 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 | |                                              |
| RESISTANCE EXERCISE STUDIES |                                           | Post exercise vs pre exercise:                           | Post exercise vs pre exercise:               |
| Comstock et al. 2013        | • Not Measured                             | • PD ↑ 1.6-fold (p < .05) in lean group immediately post-ex vs pre-ex, and ↑ 1.8-fold 24hrs post-ex | • Fatigue ↑ 4.1-fold (p < .05) in lean group immediately post-ex vs pre-ex |
|                             |                                           | ↑ 3.4-fold (p < .05) in WHO 1 group immediately post-ex vs pre-ex | ↑ 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 | ↑ 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)
### Table 3. (Continued)

| STUDY                     | PSYCHOLOGICAL WELL-BEING / POSITIVE EFFECT | PSYCHOLOGICAL DISTRESS / NEGATIVE AFFECT / STATE ANXIETY | FATIGUE                                                                 |
|---------------------------|------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------|
| Levinger et al. 2009      | Post exercise vs pre exercise:           | • No significant change (p > .05)                       | Post exercise vs pre exercise:                                        |
|                           | • PWB ↑ (p < .002) in all women post-ex vs pre-ex |                                                        | • Fatigue ↑ ~29% (p < .029) in men post-ex vs pre-ex                  |
|                           | • No significant change (p > .05) in men  |                                                        | • No significant change (p > .05) in women                            |
| COMBINATION EXERCISE STUDY | Post exercise vs pre exercise:           | Post exercise vs pre exercise:                         | • NotMeasured                                                          |
| Maraki et al. 2005        | • PA ↑ ~48% (p < .003) in morning-ex vs pre-ex; ↑ ~23% (p < .009) in evening-ex | • NA ↓ 20% (p < .027) in morning-ex vs pre-ex          |                                                                        |
|                           | Control vs exercise:                     | • ↓ ~5% (p < .042) in morning control vs pre-session   |                                                                        |
|                           | • PA ↑ 30% (p < .014) in morning session vs pre-session | • No change (p > .05) in NA in evening-ex session      |                                                                        |
|                           | Control vs exercise:                     |                                                        |                                                                        |
| COMPARATIVE EXERCISE STUDY | Post exercise vs pre exercise:           | • NA ↓ ~25% (p < .012) in all exercise groups          | • Fatigue ↑ ~74% (p < .017) in weight-lifting class post-ex vs pre-ex  |
| McGowan et al. 1991       | • No significant change (p > .05)         | combined post-ex vs control                           |                                                                        |
|                           |                                          |                                                        |                                                                        |
| Szabo et al. 1998         | • No significant change (p > .05)         | Aerobic exercise vs control:                         | Aerobic exercise vs control:                                          |
|                           |                                          | • No significant change (p > .05)                      | • No significant change (p > .05)                                     |
|                           |                                          | Anaerobic exercise vs control:                        |                                                                        |
|                           |                                          | • No significant change (p > .05)                      |                                                                        |

Abbreviations: during-ex, during exercise; evening-ex, evening exercise; HR\textsubscript{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 \(\geq 30\) kg/m²) 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.30 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,73 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 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.53 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. 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. 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. 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. 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. 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, whereas another study reported very large increases in fatigue in both men and women who are of normal weight and obese. 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. 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. 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. 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. 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/m²), and only 2 of those used obese individuals (BMI ≥ 30 kg/m²). 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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