



Original research

Efficacy and feasibility of HIIT training for university students: The Uni-HIIT RCT[☆]

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ABSTRACT

Objectives: The primary aim of this study was to evaluate the preliminary efficacy and feasibility of an 8-week high-intensity interval training program (Uni-HIIT) for young adult students in a university setting. **Design:** Randomised controlled trial.

Method: Uni-HIIT was conducted at the University of Newcastle, Australia (February–June, 2017). Participants were university students 18–25yrs ($n = 53$; 20.38 ± 1.88 yrs) randomized into the Uni HIIT program ($n = 26$) or wait-list control ($n = 27$) condition. Participants were required to attend up to three HIIT sessions/week for 8-weeks which included a variety of aerobic and muscular fitness exercise combinations lasting 8–12 minutes (using 30:30 sec rest:work intervals). The primary outcome was cardio-respiratory fitness (CRF) (20mSRT), and secondary outcomes included muscular fitness (standing jump, push-ups), body composition (InBody), executive function (Trail Making Test), anxiety levels (State Trait Anxiety Inventory) and perceived stress (Perceived Stress Scale). Linear mixed models were used to analyse outcomes and Cohen's d effect sizes were calculated. Process evaluation measures of recruitment, retention, attendance and satisfaction were conducted.

Results: A large significant group-by-time effect resulted for CRF [8.4 shuttles (95% CI(2.9–13.9), $P = 0.004$, $d = 1.08$) and muscular fitness [4.0 repetitions (95% CI(1.2–6.8), $P = 0.006$, $d = 0.99$), and moderate effect size was observed for Trail B [-5.9 seconds (95% CI(-11.8–0.1.0), $P = 0.052$, $d = 0.63$]. No significant intervention effects were found for body composition, standing jump, anxiety or perceived stress ($P > 0.05$). High ratings of participant satisfaction (4.73), enjoyment (4.54) and perceived value (4.54) were observed.

Conclusion: This study demonstrates the efficacy and feasibility of delivering a novel HIIT program in the university setting.

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Practical implications

- Combining aerobic and muscular fitness exercises in a low-dose HIIT program is effective for improving cardio-respiratory and muscular fitness, and executive function in young adults.
- Universities provide a feasible setting for the delivery of HIIT programs for young adults.

- Young adults report high satisfaction and enjoyment of Uni-HIIT, which is a multi-modal, low dose HIIT training program than provides program choice and promotes vigorous physical activity.
- An 8-week Uni-HIIT program was effective for facilitating improvements in aerobic and muscular fitness outcomes, but a longer program may be necessary to make significant changes in psychological outcomes or measures of body composition.
- Measures to promote and improve program attendance by university students need to be developed.

[☆] Trial Registration: Australian New Zealand Clinical Trials Registry: ACTRN12617000178347.

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1. Introduction

Physical inactivity is a serious public health concern for people of all ages and is now the fourth leading risk factor for global mortality¹. The transition period from adolescence into adulthood

coincides with a marked reduction in physical activity participation, with more than 50% (and up to 80%) of young adults (18–25 years) failing to meet physical activity guidelines². There is now strong and consistent evidence supporting the dose-reponse relationship between physical activity and improvements in health outcomes, and for the additional health benefits achieved when young adults maintain high levels of cardiorespiratory fitness^{3,4}. Yet, low levels of physical activity and fitness in adulthood are enduring problems, and physical activity and fitness interventions have been only moderately effective⁵.

Young adults entering university generally have positive attitudes towards physical activity and strong intentions to be regularly active, but unfortunately, do not follow through with these intentions⁶. The transition into adulthood, coupled with the added pressures associated with academic studies, work commitments and social life, makes it difficult for many students to maintain the physical activity routines they established during adolescence⁷. University campuses provide multiple, but often under-utilized, opportunities and resources for promoting physical activity in a positive and enjoyable environment⁸.

A growing body of literature supports the potency of high-intensity interval training (HIIT) for improving physical and psychological health-related outcomes^{9,10}. HIIT generally consists of high-intensity exercise bouts interspersed by a rest period between exercises (e.g., 30 seconds of high-intensity activity, followed by 30 seconds of rest, repeated for a total of 7 minutes). The main appeal of HIIT is that this type of training can be completed in a short period of time compared to traditional aerobic training, whilst resulting in comparable physiological adaptations. Recently, our research team reported the benefits of combining traditional HIIT training with body weight resistance exercises for improving fitness outcomes¹¹ and mental health¹² in adolescents. Despite evidence supporting the benefits of HIIT in laboratory settings and secondary schools, no previous study has evaluated the efficacy of this type of training delivered in a 'real world' setting for young adults. Therefore, primary aim of this investigation was to evaluate the efficacy and feasibility of a novel 8-week HIIT program (Uni-HIIT) incorporating resistance training in a sample of young adult students in a university setting.

2. Materials and methods

The study design was a randomized controlled trial with a wait-list control group. Assessments were conducted at baseline (February–March, 2017) and immediately post-intervention (June 2017). Ethics approval for the study was provided by the University of Newcastle (UoN) Human Research Ethics Committee and study participants provided written informed consent prior to participation in the study.

Male and female students at UoN aged 18–25 years, with no existing medical conditions or injuries preventing participation in physical activity, were recruited to participate in the intervention (via pamphlets, Facebook, UoN Website). Power calculations were based on change in the primary outcome of cardio-respiratory fitness. Based on our previous study¹¹, a between-group difference of 10 laps on the 20mSRT (~4.26 ml/kg/min) was considered achievable over the study period. Assuming a standard deviation of 9 laps, 80% power with alpha levels set a 0.05, it was determined that a minimum of 20 participants per group would provide adequate power to detect statistically significant effects, assuming a drop-out of 15%.

The Uni-HIIT intervention was an 8-week intervention supervised by a female member of the research team. Students were asked to participate in three HIIT sessions per week (choosing from any of the six available co-ed sessions) lasting 8-minutes

(weeks 1–4), 10-minutes (weeks 5–6), and 12-minutes (weeks 7–8) in duration, and a work to rest ratio of 30secs:30secs. All HIIT work intervals involved varied combinations of aerobic (e.g., shuttles, skips, bear walks) and core resistance (e.g., push-ups, squats, sit ups) exercises using either body weight or basic equipment (e.g., sports balls or 2 kg medicine balls). For example, a 30 sec work interval may include repeated bouts of four push-ups followed by a 5 m shuttle. Based on a recent investigation reporting the effectiveness of variety in exercise settings on exercise adherence and motivation in adults¹³ a variety of HIIT programs were made available for participants to choose from (i.e., Sport HIIT, Gym HIIT, Combat HIIT, and Brain HIIT). Each themed session involved adaptations of the basic exercise combination (e.g., Combat HIIT included squat kicks and squat punches, Brain HIIT included shuttle runs while answering questions, and Sport HIIT used shuttle style basketball dribbling as an aerobic task)(Appendix C includes example work intervals). Additionally, adherence, engagement, motivation and enjoyment were targeted through high quality program delivery using the Supportive, Active, Autonomous, Fair and Enjoyable (SAAFE) principles¹⁴. Participants wore Polar H7 heart rate monitors connected to the Polar Team iPad application, monitored by a staff member and displayed on the screen for participants to view during sessions. Participants wore Polar H7 heart rate monitors connected to the Polar Team iPad application, monitored by a staff member and displayed on the screen for participants to view during sessions. A target Max.HR of 85% or above was promoted to ensure appropriate exercise intensity was reached and maintained during work.

Participants randomized to the control conditions were asked to continue with their usual physical activity routines during the intervention period, and received the Uni-HIIT program once the intervention and follow-up assessments were completed. Assessments were conducted at the UoN by qualified research assistants. To assure accuracy and consistency a protocol manual was followed, and where possible the same researcher conducted the tests for all participants at both time-points. Participants were stratified by sex, using a computer-based random number-producing algorithm and completed by a researcher not involved in the project to ensure an equal chance of allocation to each group.

Physiological measures: Standard testing procedures from the FITNESSGRAM® testing manual¹⁵ were followed for the 20mSRT measuring *cardiorespiratory fitness* (primary outcome), and 90⁰⁰ push-up test measuring *muscular fitness* (upper body). The standing long jump test was used to assess lower body muscular power¹⁶, and assessments of *body composition* (weight, skeletal muscle mass and body fat mass) were measured using bioelectrical impedance analysis (model 720; Inbody). Body mass index (BMI) was calculated from measured height and weight data ($BMI = \text{weight (kg)} / (\text{height (m)})^2$).

Psychological Measures: *Perceived stress* was assessed using the Perceived Stress Scale (PSS)¹⁷ and included 10 items rated on a 5 point Likert scale (0 = never to 4 = very often) (e.g., "In the last month, how often have you felt nervous or stressed?"). *Anxiety* was assessed using the 6-item short-form state scale of the Spielberger State-Trait Anxiety Inventory (STAI) using a 4 point Likert scale (1 = not at all to 4 = very much) (e.g., "I feel calm")¹⁸.

Cognitive Measures: *Executive function* was assessed using the trail making test (TMT)¹⁹ and involved a two-part visual task (Trail A and B). Three scores of cognitive flexibility were determined [(B-A); (B/A); and B].

Process evaluation: The Feelings State questionnaire was a one-item questionnaire administered pre- and post HIIT sessions, asking participants to respond the question 'How are you feeling right now?' (-5 = very bad to +5 = very good)²⁰. To monitor exercise intensity (target: efforts >85% of heart rate maximum), participants were fitted with Polar H7 heart rate monitors, which were connected to a

central iPad application (Polar Team), and the mean heart rate for the entire session and the mean maximum heart rate was tracked over the study period. Data regarding recruitment, adherence and retention rates were examined; and the intervention group completed an evaluation survey.

Statistical analyses of all outcomes was conducted using linear mixed models using IBM SPSS Statistics for Windows (Version 20) (SPSS, INC 2010, IBM Company, Armonk, NY) with alpha levels set to 0.05. The mixed models were used to assess the impact of treatment (Uni-HIIT or control group), time (treated as categorical with levels that include baseline and immediate post-intervention follow-up) and the group-by-time interaction. Mixed models are consistent with the intention-to-treat principle. Kolmogorov-Smirnov test was used to determine normality of data and 95% confidence intervals calculated. Cohen's *d* was calculated by dividing the mean difference in change by the pooled standard deviation of change for each variable. Associations between changes in cardiorespiratory fitness and changes in executive function were determined using Pearson's correlation coefficient.

3. Results

Baseline demographic data are presented in Table 1. Table 2 details all results for primary and secondary outcomes.

For the primary outcome cardiorespiratory fitness, there was a significant group-by-time interaction and a large effect size observed for 20mSRT [adjusted mean difference = 8.4 levels (95% CI (2.8–13.9), $P=0.004$, $d=1.08$] or 1.78 ml/kg/min VO_2 max (calculated using $41.76799 + (0.49261 \times \text{Shuttles}) - (0.00290 \times \text{Shuttles}^2) - (0.61613 \times \text{BMI}) + (0.34787 \times \text{gender} \times \text{age})^{21}$).

For the secondary outcome muscular fitness, there was a significant group-by-time interaction and large effect size were observed for upper body muscular fitness [4.0 reps (95% CI (1.2–6.9), $P=0.006$, $d=0.99$] but no significant group-by-time difference for standing long jump ($P=0.941$, $d=0.06$). No significant effects were found for body composition outcomes or psychological outcomes (perceived stress or anxiety). There was a significant group-by-time difference and moderate effect size observed for executive function for Trail B [-5.9 (95% CI (-11.8–0.1), $P=0.052$, $d=0.63$], but no significant differences were observed for Trail Score 1 (B-A) or Trail Score 2 (B/A).

Note: There was a significant association between changes in cardiorespiratory fitness (20mSRT) and changes in executive function (TrailB) (Pearson's Correlation $r=-0.35$, $P=0.041$).

The flow of participants through the study is displayed in Fig. 1 (Appendix A). A member of the research team conducted all 24 sessions from which students had an average attendance of 66.7% (54.5% of participants attended 2+ sessions/week). There was a decline in attendance by some participants towards the end of the intervention. The average heart rate per session was 82.2%Max.HR (work and rest intervals) and the average maximum heart rate per session was 92.8%Max.HR. In week 1, Gym and Sport HIIT options were available; in weeks 2–5 Gym, Sport and Combat HIIT options were available; and in weeks 6–8 Gym, Sport, Combat and Brain HIIT options were available – with approximately 60% of participants choosing to complete Gym HIIT each week. Retention was 75.5% and the evaluation survey results are displayed in Table 3 and indicate: a) high overall enjoyment of the program (mean scores *enjoyment* items = 4.54/5; b) high perceptions that the Uni-HIIT program was beneficial (mean scores *perceived benefits* items = 4.06/5); and c) that participants intend to continue to participate in physical activities (mean score *future plans* = 4.31/5). Furthermore, participants indicated that they were particularly satisfied (4.73/5) with the low-dose sessions and rated the GYM HIIT

sessions most favourably (mean = 4.59/5). Results from the feelings state questionnaire indicated an average change of +1.63 for all participants across all sessions (mean pre session = 2.33/5, mean post session = 3.96), indicating an overall positive impact on affective response to participation in Uni-HIIT sessions (Appendix B Fig. 2).

4. Discussion

The primary aim of this study was to evaluate the feasibility and efficacy of an 8-week high-intensity interval training program (Uni-HIIT) in a sample of young adults in a university setting. Participant rated the program highly with regard to overall satisfaction, enjoyment and perceived value, but only 55% of participants attended two or more sessions per week for the eight weeks. Our results demonstrate a large intervention effect for the primary outcome, cardiorespiratory fitness. We also observed large and moderate intervention effects for muscular strength and cognitive function, respectively. Taken together, our findings provide preliminary evidence for the efficacy and feasibility of this novel version of HIIT when implemented in a 'real world setting' with young adults.

Given that cardiorespiratory fitness is important for achieving optimal health outcomes in adults, the large effects observed for cardiorespiratory fitness in this study are important, especially given that sessions lasted only 8–12 minutes. A 16-week HIIT study targeting young adults (mean age 24.3yrs) conducted by Greenlee and colleagues²² failed to produce significant improvement in 20mSRT performances using 70 min sessions. The improvements in cardiorespiratory fitness in our study, and evidenced in other vigorous style physical activity programs²³, may be due to promotion of and adherence to the heart rate targets (> 80% HR max.); or the unique combination of high-intensity aerobic and muscular fitness exercises included during work intervals. Additionally, time poor young adults may be more willing to work at high intensities in sessions when there is a low-dose protocol (e.g., 8 minutes) using short duration work intervals (30secs) in preference to longer sessions.

The significant improvement and large effect for upper-body muscular fitness in the Uni-HIIT study is encouraging given the evidence linking muscular fitness to a range of important health outcomes²⁴. For example, a pooled analysis of 11 population cohorts revealed that participation in any strength-promoting exercise was positively linked to all-cause and cancer mortality in adults, with the authors concluding that adults should participate in strength exercise over and above standard physical activity guidelines²⁴. More specifically, in a large sample of university students, low and moderate levels of muscular fitness were significantly associated with increased cardio-metabolic risk and lipid-metabolic cardiovascular risk index, with high levels of muscular fitness having the highest levels of cardio-metabolic protection²⁵. Our findings are not surprising, given the inclusion of a range of challenging upper-body resistance training exercises in each of the HIIT sessions that utilize movements and muscle groups that may not be typically included in normal daily activities of participants (e.g., push-up variations, bear walks, front support exercises).

Similar to Greenlee's 16-week HIIT intervention²², Uni-HIIT failed to produce any notable improvements in lower body muscular fitness despite the intervention including numerous body weight exercises involving lower body muscle activation (e.g., jumping, squats, lunges). These results may due to the consistent load used to perform low repetition bouts of lower body exercises during sessions and across the 8-weeks intervention. Using the training principle 'overload', programmed increases in load are required to make significant gains in muscular fitness, but the use of weight training equipment would compromise the feasibility and potential scalability of the Uni-HIIT program (i.e. using lim-

Table 1
Baseline Data (Australia, March 2017).

Characteristics	Control (n = 31)		UNI-HITT (n = 22)		Total (n = 53)	
	Mean (SD)		Mean (SD)		Mean (SD)	
Age (y)	20.48 (2.01)		20.23 (1.72)		20.38 (1.88)	
Study Level (1-5 years)	2.06 (1.37)		2.00 (0.93)		2.04 (1.19)	
SES status (SEIFA Decile 1-10)	5.90 (1.99)		4.23 (1.82)		5.21 (2.08)	
Body Mass Index (kg/m ²)	23.10 (4.20)		24.11 (4.06)		23.53 (4.14)	
	No.	%	No.	%	No.	%
Sex (male)	10	32.30	8	36.40	18	34.00
Country of Birth (Australia)	27	87.10	20	90.90	47	88.70
Language (English)	30	96.80	20	90.90	50	94.30
ATSIL	4	12.90	1	4.50	5	9.40
First in Family	7	22.60	8	36.40	15	28.30
Overweight or obese	9	29.03	8	36.36	17	32.08

SD = standard deviation; No. = number; ATSIL = Aboriginal Torres Strait Islander; % = percentage; SES = socio-economic status measured using the SEIFA for participants residency (socio economic index for areas; 1 = low SES)

Table 2
Uni-HIIT Study intervention effects (by treatment group) – Physiological, Psychological and Cognitive Outcomes (Australia, 2017).

Measure	Physiological Outcomes				Adjusted Difference in Change (95% CI) ^a	Group*Time P value	Cohen's d Effect Size
	Control Group (n = 26)		Uni-HIIT (n = 27)				
	Baseline (SD)	8-week posttest (SD)	Baseline (SD)	8-week posttest (SD)			
20mSRT (laps)	49.4 (20.36)	49.8 (19.91)	54.0 (23.18)	62.8 (20.40)	8.4 (2.8-13.9)	0.004	1.08
Standing Jump (cm)	151.4 (35.66)	158.9 (31.95)	154.0 (37.29)	161.1 (35.09)	-0.4 (-10.5-9.8)	0.941	0.06
Push-up (No.)	14.0 (13.94)	14.1 (8.12)	13.3 (7.46)	17.5 (8.45)	4.0 (1.2-6.8)	0.006	0.99
Skeletal muscle mass (kg)	28.6 (7.42)	28.6 (6.83)	31.6 (7.10)	31.8 (7.80)	0.2 (0.5-1.0)	0.571	0.19
Body fat mass (kg)	15.34 (7.87)	16.1 (8.29)	18.3 (10.13)	19.3 (10.64)	0.4 (-0.9-1.7)	0.539	0.16
Body Mass Index (kg/m ²)	22.96 (4.20)	23.25 (4.40)	24.17 (4.06)	24.55 (4.27)	0.19 (-0.2-0.6)	0.301	0.33
Body fat (%)	23.0 (9.06)	23.7 (9.00)	23.9 (8.53)	24.9 (9.05)	0.2 (-1.4-1.9)	0.767	0.04
Psychological Outcomes							
Perceived stress	21.9 (2.76)	17.68 (5.18)	19.52 (4.19)	14.17 (5.58)	-1.1 (-4.2-2.0)	0.476	0.20
Anxiety	13.9 (1.47)	14.20 (1.83)	14.29 (1.50)	14.39 (2.37)	-0.2 (-1.5-1.1)	0.709	0.02
Cognitive Outcomes							
Trail B	49.9 (14.67)	45.8 (15.32)	51.9 (18.31)	41.9 (13.59)	-5.9 (-11.8-0.1)	0.052	0.63
Trail Score 1 (B-A)	30.1 (13.20)	25.4 (12.33)	30.0 (16.54)	21.9 (9.56)	-3.4 (-10.3-3.6)	0.334	0.36
Trail Score 2 (B/A)	2.6 (0.80)	2.3 (0.58)	2.5 (0.79)	2.21 (0.38)	0.12 (-0.4-0.6)	0.623	0.02

Abbreviations: BMI, body mass index; CI, confidence interval; SD, standard deviation; ^aAdjusted mean difference and 95% CI between Uni-HIIT™ and control groups after 8-weeks (Control – Intervention) –adjusted for baseline scores; ^b Within group change over time; Cohen's d calculated as d = mean difference in change scores/pooled variance; MVPA, moderate-to-vigorous physical activity; VPA, vigorous physical activity.

ited equipment and organisation). Furthermore, muscular power (as measured by the standing jump) is more difficult to improve than muscular strength or endurance²⁶.

The Uni-HIIT program had no effect on any of the measures of body composition. Two recent reviews concluded that HIIT training can induce modest body composition improvements in overweight and obese individuals^{23,27}; but the research supporting the effectiveness of short duration HIIT for impacting on measures of body composition in normal weight young adults is limited²³. Additionally, nutritional behaviours were not targeted (or evaluated) in this study, limiting the scope of the study to influence body composition outcomes. The lack of findings for both the standing jump and measures of body composition may be partly due to attendance rates, with 45% of participants in the intervention group failing to adhere to the three recommended sessions per week. Attendance may have been effected by session times (8.15am Mon-Fri), or by the negative affect often elicited through participation in vigorous exercise in some individuals.

The Uni-HIIT program found a significant intervention effect for executive function, and changes in cardiorespiratory fitness were associated with changes in executive function. Although causality is not established, our findings will add to the emerging evidence confirming an association between cardiorespiratory fitness and brain function in young adults²⁸. Our research team recently pro-

duced similar improvements in executive function following a HIIT intervention targeting adolescents in the school setting¹². And although this fast growing research domain has primarily targeted children and older adults, new evidence has emerged to support the beneficial effects of multimodal training (using a combination of cognitively and physical demanding exercises) for facilitating improvements in executive function and learning in young adults and adolescents²⁹.

In this study, there were non-significant group-by-time improvements for measures of perceived stress and anxiety. Physical activity researchers are looking to build evidence for the effectiveness of high-intensity exercise and improved fitness levels for preventing and treating psychological issues evident in people of all ages and population sub-groups⁴; and our findings will add to the limited literature. It is possible that our findings were affected by the length of the intervention program, given that interventions lasting more than three months have shown to be more successful in improving mental health outcomes in young people³⁰.

Assessing feasibility of physical activity programs is an important step in the evaluation process. To the authors' knowledge, this is the first study investigate the impact of a HIIT intervention (combining cardiorespiratory and muscular fitness exercises) for young adults delivered in a university setting. High ratings of satisfaction, enjoyment and perceived value indicate that program was well

Table 3
Evaluation Survey Uni-HIIT (Australia, 2017).

Evaluation Survey		N = 27	
		Mean	SD
<i>Perceived benefits</i>			
Uni-HIIT helped...			
1.	to improve my health and wellbeing	4.27	0.63
2.	to improve my overall fitness	4.14	0.64
3.	to improve my muscular fitness	4.00	0.87
4.	to improve my aerobic fitness	4.14	0.77
5.	to improve my exercise skills/technique	3.86	0.89
6.	improve my performance in other sports &/or physical activity	4.14	0.77
7.	improve my motivation to exercise	4.05	1.21
8.	me feel more motivated in my University studies	3.59	1.05
9.	me feel more energetic	4.23	0.61
10.	me fit exercise into my weekly schedule	3.77	1.07
11.	Uni-HIIT enabled me to do exercise in a time-efficient way	4.00	1.11
12.	enabled me to do exercise in a time-efficient way	4.50	0.74
<i>Enjoyment of the program</i>			
1.	I enjoyed participating the Uni-HIIT sessions	4.41	0.73
2.	I enjoyed doing the program with others students/my friends	4.55	0.60
3.	I think all Uni students should have the opportunity to try Uni-HIIT	4.86	0.48
4.	I enjoyed having a choice of HIIT programs/exercises to select from	4.32	0.78
<i>Rating of self</i>			
1.	I feel better about myself having participated in Uni-HIIT	4.27	0.83
2.	I put in a lot of effort during the Uni-HIIT sessions	4.32	0.84
3.	I would like to know if my fitness has changed after participating	4.64	0.58
4.	I made an effort to make sure I got to Uni-HIIT sessions	3.91	1.02
5.	I consistently made it to 3 sessions per week	3.14	1.49
6.	Overall I am satisfied with my involvement in the Uni-HIIT program	3.82	1.14
<i>Future plans</i>			
1.	In the future I plan to participate in muscle strengthening physical activity	4.32	0.78
2.	In the future I plan to participate in aerobic activities	4.32	1.09
3.	In the future I plan to join a gym, fitness centre or health club	4.18	1.05
4.	In the future I plan to participate in HIIT training (at home or other)	4.41	0.80
<i>Enjoyment (components)</i>			
1.	I enjoyed participating in Gym HIIT sessions	4.59	0.59
2.	I enjoyed participating in Sport HIIT sessions	4.14	0.94
3.	I enjoyed participating in Combat HIIT sessions	3.86	1.25
4.	I preferred to participate in the sessions on my own (no partner)	3.32	1.25
5.	I preferred to participate in the sessions with a partner	4.00	0.87
6.	I liked the fact that the sessions were quick (between 8min–12 min)	4.73	0.65

received by students in the university setting. Notably, the majority of participants felt that the program should be available to all university students, enjoyed the short sessions and were interested to know how if their fitness improved. However, one issue was attendance, as only approximately 55% of participants attended 2+ sessions/week. The development of a Uni-HIIT mobile application to promote and record sessions completed at home may also be an alternate strategy for improving program adherence during and beyond the program. This would address the changing nature of Australian universities, whereby University students are no longer a captive audience due to the flexibility of course delivery (e.g., on-line delivery, non-compulsory lectures), part-time studies, and students frequently juggle multiple responsibilities (such as part-time work and families) – resulting in a ‘fly in/fly out’ approach to university studies.

Major strengths of this study are the RCT design, valid and reliable assessments of physical, mental and cognitive outcomes, and assessor blinding at baseline. Limitations of the study included a small sample, the uneven mix of male and female participants, and the short length of the intervention. Given that Uni-HIIT was effective for improving study outcomes, well-received by participants, and required very little time, space, resources, organisation and supervision, the potential of the program in a range of settings could be explored in future studies. For example, the supervisory role of the research team could be taken on by another student

or program “Champion” in alternate settings (workplace, schools, retirement villages).

5. Conclusion

This novel program combined aerobic and resistance-training exercises using a variety of short duration HIIT programs to address current levels of physical inactivity and low levels of fitness evident in this population sub-group. The Uni-HIIT program produced significant improvements in cardio-respiratory and muscular fitness, and executive function in young adult students. Students also rated the program highly. In the future there is a need to conduct an evaluation of a longer duration Uni-HIIT program for improving mental health outcomes, and a larger trial investigating the effectiveness and sustainability of the Uni-HIIT program as a scalable approach for use across various post-school settings.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jsams.2018.11.016>.

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