

# Impact of high-intensity interval training including Indigenous narratives on adolescents' mental health: a cluster-randomised controlled trial

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**G**lobally, 10-12% of adolescents are estimated to suffer from a mental health disorder,<sup>1</sup> with lower income communities and ethnic minorities disproportionately affected.<sup>2</sup> New Zealand (NZ) youth are not immune, with concerning rates of depression, psychological difficulties and suicidal behaviour.<sup>3</sup> Many young people fail to achieve significant benefits from talking therapies and medications,<sup>4</sup> and most youth in distress do not seek this type of help, particularly Indigenous Māori, and Pacific young people in New Zealand.<sup>5</sup>

Physical activity (PA) appears to be effective for reducing depressive symptoms and improving anxiety and self-esteem in youth, particularly among those with an existing mental health issue,<sup>6-8</sup> and there is a positive relationship between fitness and mental health.<sup>8</sup> Underpinning such effects include potential neurobiological, psychosocial, behavioural and physiological mechanisms.<sup>9</sup> Unfortunately, PA declines rapidly in adolescence,<sup>10</sup> so innovative solutions are therefore needed to address the public health challenges of declining mental health and PA among adolescents. High-intensity interval training (HIIT) is a form of vigorous physical activity with established efficacy for a range of health outcomes in adolescents<sup>11,12</sup> and potential for improving mental health in the general population, but the extent to which these effects are greater than other forms of PA remain unclear,<sup>13</sup> including in

## Abstract

**Objectives:** We investigated the efficacy of teacher-delivered high-intensity interval training (HIIT) with Indigenous narrative options on the mental health of school students in low–mid socioeconomic areas, compared to standard curriculum physical education practice.

**Methods:** A cluster-randomised controlled trial was conducted in eight schools (N=368, age range 11–13 years) over 16 weeks. The primary outcome was the Strengths and Difficulties Questionnaire (SDQ) score. Generalised linear mixed models, controlling for the SDQ at baseline were applied, expressed as  $\beta$ , 95% confidence intervals, standardised effect, and p-value. Focus groups elicited experiences with participating in and delivering the intervention.

**Results:** There were no clear effects for SDQ total score ( $\beta$  -0.15, CI -0.98 - 0.67, SE 0.42,  $p=0.714$ ). Teachers did not deliver the Indigenous narrative options consistently owing to the perceived preparation needed and lack of confidence.

**Conclusions:** HIIT delivered in this manner had no effect on self-perceived psychological difficulty or mental wellbeing in a cohort of young adolescents.

**Implications for public health:** Future research should continue to explore opportunities to improve mental wellbeing via physical activity, but HIIT should not be implemented as a universal intervention for mental health gains alone. Teachers need more support to utilise Indigenous narratives as part of HIIT delivery.

**Key words:** mental health, exercise, school, youth, Indigenous

adolescents.<sup>14</sup> Given the feasibility<sup>15,16</sup> of delivering HIIT in schools, investigation of its effects on mental health warrants research.

Mental health is also impacted by aspects of identity, such as cultural 'connectedness'.<sup>17</sup> Accordingly, disconnection from culture and the ability to express aspects of cultural identity have been shown to negatively affect the mental health of Indigenous people.<sup>18</sup> While the restoration and revitalisation of Indigenous people is

complex and multi-faceted, physical activity may provide an opportunity to strengthen cultural identity<sup>19,20</sup> and connection if conducted in culturally relevant ways. Thus, consideration should be given to the manner in which physical activity is administered,<sup>21,22</sup> including components that acknowledge the value of cultural knowledge and Indigenous practice.<sup>23-25</sup> Indigenous scholars have highlighted the value of Indigenous knowledge, narratives, and values underpinning health initiatives,

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including physical activity specifically,<sup>20,26-28</sup> to improve health and reduce health inequities. If conducted appropriately, 'culturally enhanced' sessions may have positive effects beyond Māori students, so that non-Māori students become more familiar with, and develop a greater appreciation for the Indigenous knowledge and histories of New Zealand. Enhancing cultural relevance should be considered in a bi-cultural society such as in New Zealand. Hence, we investigated the impact of teacher-delivered HIIT inclusive of Indigenous narratives on the mental health and wellbeing of young adolescents in low-mid socioeconomic areas, compared to standard New Zealand curriculum physical education (PE) practice.

## Methods

Ethics approval was obtained from the research ethics committee of the Auckland University of Technology, New Zealand. This cluster-randomised controlled trial (C-RCT) adhered to the Standard Protocol Items: Recommendations for Interventional Trials and Consolidated Standards of Reporting Trials (CONSORT) guidelines; trial registration ID: ACTRN12618000301268.

## Participants

Eight schools (students aged 11–13 years) were recruited from a metropolitan area via direct email and phone calls. The school inclusion criterion was location in communities of the two lowest deciles of the relative index of inequality<sup>29</sup> (known as 'decile' categories). The exclusion criterion was if a school was currently receiving, or had recently received, an intervention that could conceivably influence the outcomes assessed, such as a PA program from an external provider. The individual student participant exclusion criterion was if physical participation in normal PE curriculum delivery was restricted or prohibited owing to ongoing injury or serious medical condition. Two class groups were selected by a school leader to be subsequently randomised by class (post-baseline assessments, by sealed opaque envelopes) to either the intervention or control (standard curriculum delivery) conditions. Assessments were conducted at baseline, and post-intervention (16 weeks, punctuated by a two-week school break). Assuming an effect size of 0.15<sup>15</sup>,  $\alpha$  of 0.05 and  $\beta$  of 0.80, allowing for an estimated 5% loss to follow-up post-intervention

and low interclass correlation, we targeted recruitment of 400 study participants.

## Study intervention

The intervention was very similar to that used in the feasibility study of Harris et al.,<sup>16</sup> but included optional HIIT sessions that were framed by traditional Māori narratives, termed 'pūrākau' and 'kōrero tuku iho' (passed down stories/narratives). For example, the discovery of Aotearoa by Kupe (a well-known Pacific ancestor and explorer), or the ascension of the Atua, Tāne (a deity associated with creation stories) to obtain ngā kete o te wānanga (the three 'baskets of knowledge'). Narrative components were used to frame exercise and rest interval durations and effort levels. For example, 30 seconds of high effort exercise (attempting to reach at least 90% of maximum effort based on estimated heart rate maximum) based on a relevant high effort component of the narrative such as a 'chase', followed by 30 seconds of passive recovery, repeated 10 times consecutively. These narratives provided an innovative opportunity to connect aspects of culturally relevant stories that also related to Māori parts of the school curriculum including the use of Māori language (te reo), to physical activity (te reo kori) within the health and PE curriculum. The sessions using these narratives were developed by two of the authors and piloted in two schools over four iterative sessions with general formative feedback received after each. One author led all Māori aspects of the study and intervention (IW, Ngāti Te Ata, Te Arawa, Ngā Puhī – three Māori tribes of New Zealand's North Island) and is an exercise physiologist, senior research fellow and co-director of Taupua Waiora Centre for Māori Health Research, with 16 years of experience conducting Kaupapa Māori research (research underpinned by Māori values), including working with Māori communities and organisations to achieve culturally relevant outcomes. The other (NH) led the development of exercise prescription parameters such as work and rest intervals, and how the pūrākau could be used within such prescription.

At the start of the school term, after baseline assessments, a professional learning session was conducted with all eight intervention class teachers (all generalists) collectively, informing them how to deliver the HIIT intervention, incorporating principles of effective delivery.<sup>22</sup> The HIIT sessions were

designed to fit within 15 minutes during twice-weekly PE periods per week in school time, delivered by the classroom teacher. A classroom set of heart rate monitors (Polar H10™, Finland), an iPad™ with brief exercise videos, and subscription to an app ('Selfloops™', Italy) provided the function of both recording heart rates for further analyses and displaying heart rates on the class screen in real-time during HIIT sessions. The specified target heart rate was 90% of the estimated heart rate maximum towards the end of most intervals.

## Control

The control classes continued with their usual practice PE delivery using the standard New Zealand curriculum. The intention was to compare the relative efficacy of HIIT with the current PE delivery as it is (i.e. standard practice).

## Outcomes

Assessments were conducted by trained research assistants who were blinded to group allocation.

The primary outcome was the Strength and Difficulties Questionnaire (SDQ) total score.<sup>30</sup> SDQ is a self-report measure of psychological adjustment designed for use with 11–16-year-olds. It is divided into five scales of five items, which score for conduct problems, hyperactivity, emotional symptoms, peer problems and pro-social behaviour; all but pro-social behaviour were summed to generate a total difficulties score, which gave an indication of the degree of overall distress and social impairment associated with the psychological attributes of the adolescent, with a possible range from 0 to 40. Lower scores indicate fewer psychological difficulties.

## Secondary outcome measures

Mental wellbeing was assessed with the Warwick-Edinburgh Mental Wellbeing Scale,<sup>31</sup> a 7-item questionnaire. Participants respond on a 5-point scale that best described the frequency with which they experience thoughts such as "I've been feeling optimistic about the future" over the past two weeks.

Executive function was assessed using the Trail Making Test (TMT); a measure of visual attention, speed, scanning, speed of processing and mental flexibility.<sup>32</sup> The TMT involves a two-part visual task in which participants are required to draw a line from one point to the next as quickly as possible.

Self-efficacy for HIIT was determined using the High-Intensity Interval Training Self-Efficacy Questionnaire,<sup>33</sup> a 6-item 5-point scale questionnaire. Participants also rated their own perceived fitness with the International Fitness Scale.<sup>34</sup>

*Autonomous motivation* for physical activity was assessed using the 8-item validated 'Behavioural Regulations in Exercise Questionnaire' (BREQ),<sup>35</sup> examining benefits, fun, importance, enjoyment, effort, pleasure, restlessness and satisfaction related to exercise. The total sum score of identified (e.g. *I value the benefits of exercise*), and intrinsic (e.g. *I exercise because it's fun*) regulation subscales from the BREQ were used for analyses.

Cardiorespiratory (aerobic) fitness was assessed with the commonly used Progressive Aerobic Cardiovascular Endurance Run (PACER).<sup>36</sup>

The validated Resistance Training Skills Battery<sup>37</sup> was used to determine the ability to correctly perform a variety of movements, such as bodyweight squatting and lunging, and push-ups.

Body mass, stature, seated stature (to calculate 'maturity offset',<sup>38</sup> a proxy of biological maturity), and waist circumference were measured at baseline for participant characteristic descriptive purposes.

For the gathering of qualitative data through capturing student participants' perspectives on how they felt about participating in the intervention, focus groups of five to six participant students were facilitated. In addition, individual semi-structured interviews were conducted with teachers regarding how the intervention had impacted their students and themselves. The focus groups and interviews were audio-recorded and transcribed for thematic analysis, where coding identified common themes.

Intervention fidelity measures were: Students' heart rates during the HIIT sessions, and number of practical sessions delivered.

### Statistical analyses

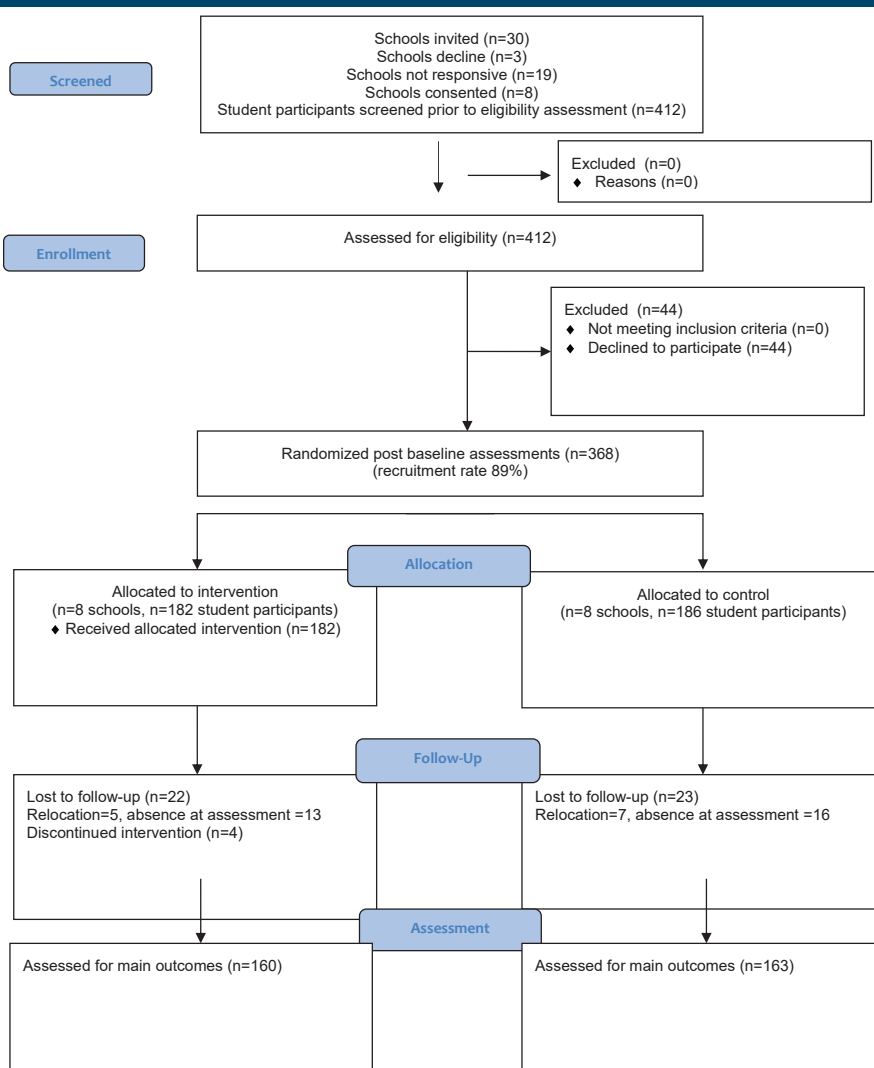
Descriptive appraisal of baseline data was carried out using Student's t-tests or Mann-Whitney-U-tests for between-group testing, depending on the distribution (normal, non-normal) of the variables. Chi-squared tests were applied for categorical variables. Intention to treat inferential appraisal of intervention effect as quantified by SDQ scores was carried out using generalised linear mixed models, controlling for the SDQ at baseline for post-intervention appraisal. School of subject (student) was applied as a random effect, inclusive of random intercepts for class. The Warwick-Edinburgh Wellbeing total score was appraised using ordered regression models, controlled for baseline score. PACER score at post-intervention was applied to final models of SDQ scores and Warwick Wellbeing scores to ascertain covariate effects on SDQ total score, and Warwick Wellbeing total score. The influence

of maturity offset, PACER score and sex as covariates on the treatment effect and outcomes and as moderator effects were appraised. Statistical analyses were carried out using Stata version 16.

### Results

Baseline descriptives for student participants are detailed in Table 1. A total of 368 students volunteered to participate (recruitment rate 89%). Lost to follow-up were 45 participants; 23 from control and 22 from intervention, owing to their absence from school at the time of testing, leaving the school during the intervention period, or withdrawal due to an injury unrelated to intervention (see Figure 1). The number of sessions delivered by teachers overall was  $19.9 \pm 7.6$  (mean  $\pm$ SD) of a total 28 scheduled (range 9–28). In two schools that delivered only nine sessions in total, the teachers were absent

Figure 1: CONSORT Diagram.



	Control N=186	Intervention N=182
Female	84	100
Male	102	82
BMI (kg/m <sup>2</sup> )	19.9 $\pm$ 2.3	20.0 $\pm$ 2.6
Age (years)	12.2 $\pm$ 0.6	12.1 $\pm$ 0.6
Maturity Offset Female (years)	0.10 $\pm$ 0.6	0.12 $\pm$ 0.7
Maturity Offset Male (years)	-2.08 $\pm$ 0.9	-2.07 $\pm$ 0.8

for a substantive period of the intervention owing to sickness. The heart rate peaks on average over all sessions was 89.9±3.2% HRmax. No adverse events occurred and there were no withdrawals.

Table 2 presents the baseline measures and intervention effects.

There was no intervention effect for the primary outcome, Strengths and Difficulties Questionnaire (SDQ) total score, or any of the SDQ sub-domain scores. There was no intervention effect on the Warwick-Edinburgh Wellbeing total score. Both the intervention and control groups significantly improved executive function (both TMT scores) but there was no group-by-time effect. The intervention group experienced significantly greater improvements than the control group in HIIT self-efficacy ( $p<0.001$ ), self-perceived fitness ( $p=0.035$ ), squat repetitions completed, ( $p<0.001$ ), and resistance training skills score ( $p=0.035$ ). There was no difference between groups in BREQ score ( $p=0.134$ ). Both the intervention and control groups significantly improved their cardiorespiratory fitness (PACER) but the group-by-time effect was not significant ( $p=0.415$ ). The adjusted models accounting for covariates of maturity offset, PACER score and sex did not result in any significant differences. Moderator effects of covariates resulted in universally non-significant differences.

In response to being asked if participation in the HIIT had changed the way they felt about

their own wellbeing, students noted an acute effect on their mood, including feelings of alertness:

*... before HIIT I might feel like, ugh. But after HIIT I'll feel a lot better and my mood got better.*

*Like after doing a block of some sleepy academic subject and then doing this to wake you up, feels really good.*

But, some students commented on a feeling of tiredness immediately post-HIIT:

*Some of us were hyped, some of us were tired.*

Many commented on their enjoyment of the class dynamic during the sessions:

*Like, you get to work with all your class and then like you cheer everyone on. It's fun.*

The majority of students stated they enjoyed the HIIT sessions:

*They were fun, and made us feel good.*

Some specifically expressed their dislike of the HIIT:

*The classroom was too small and during the winter it was too smelly.*

*It was easy to give up especially if you could get away with doing as little as possible without the teacher noticing.*

With regards to the incorporation of Māori narratives in the HIIT sessions, the concept was enthusiastically received by teachers in our professional learning session prior to the start of the intervention, with apparently genuine intention to utilise. But, despite that intention, all but one teacher did not use the narrative options with any regularity.

*I think we did it in like one. I was really bad. I wanted to... because that was probably one of my favourite things about [the professional learning session] we did before we started, was the incorporation of that... I mean we know as teachers that making stuff relevant to kids... and you cover so many different aspects of the curriculum just by adding in that story. So that was probably my favourite aspect, and it's, it was a shame that I didn't get to, kind of, use it as much as I would have liked to. But, um, yeah that's probably all on me.*

Most teachers stated they needed more specific guidance and compulsion to use the narratives:

*... if I was given more... I would of used it without batting an eyelid... because I don't know the stories. But I did try.*

Six teachers noted that the inclusion of the narratives when used did engage their class:

*They love having a story behind it and just something to go with it. And it just gives it that more, little bit more interest... my kids love stories... yeah, they loved it when we did do it.*

Two teachers felt that their class was not better engaged by the narratives, and they then stated they did not feel their use was worthwhile pursuing further:

*Really challenging with the group of kids in my class... They were much more, okay, "Let's do a HIIT, let's do it because we know that it's fitness and exercise", rather than trying to incorporate any kind of bigger picture to it.*

Three teachers expressed their reservations about entering what they perceived as a culturally unfamiliar space:

**Table 2: The baseline measures expressed as median (interquartile range) or mean±SD as appropriate, and post-intervention outcomes, with the intervention effect expressed as β with 95% confidence intervals (95% CI), standardised effect (SE), and associated p value.**

	Control			Intervention			Intervention effect			
	Baseline	Post	p	Baseline	Post	p	β	[95% CI]	SE	p
SDQ Total Score	12 (9, 17)	12.8 ± 5.3	0.802	11.0 (8, 14)	11.6 ± 5.4	0.713	-0.15	[-0.98, 0.67]	0.42	0.714
SDQ Conduct Score	2 (1, 3)	2 (1, 3)	0.930	1 (1, 3)	2 (1, 3)	0.197	0.10	[-0.21, 0.41]	0.15	0.499
SDQ Emotional Score	4 (2, 5)	3 (2, 5)	0.203	3 (2, 5)	3 (2, 5)	0.846	0.05	[-0.32, 0.41]	0.19	0.798
SDQ Hyperactivity Score	4 (3, 6)	4.5 ± 2.2	0.688	4 (2, 5)	3.9 ± 2.2	0.651	-0.15	[-0.54, 0.24]	0.20	0.458
SDQ Peer Score	2 (1, 3)	2 (1, 3)	0.342	2 (1, 3)	2 (1, 3)	0.165	-0.27	[-0.61, 0.05]	0.17	0.100
SDQ Prosocial Score	8 (6, 9)	8 (6, 9)	0.491	8 (6, 9)	8 (6, 9)	0.274	-0.04	[-0.35, 0.28]	0.16	0.814
Warwick-Edinburgh Wellbeing Total Score	26 (24, 30)	26 (23, 29)	0.020	26 (23, 28)	26 (22, 29)	0.296	0.83	[-0.05, 1.71]	0.45	0.066
Trail Making Test A (sec)	33 (27, 43)	29 (23, 36)	0.000	33 (27, 45)	29 (23, 36)	0.000	-0.43	[-2.31, 1.43]	0.95	0.650
Trail Making Test B (sec)	83 (66, 108)	68 (56, 87)	0.000	81 (66, 103)	70 (53, 88)	0.000	1.89	[-3.95, 7.72]	2.98	0.526
PACER (laps completed)	26 (16, 44)	31 (19, 47)	0.000	27 (16, 42)	32 (18, 47)	0.000	0.97	[-1.36, 3.31]	1.19	0.415
Push-up (repetitions completed)	14 (7, 23)	16 (10, 24)	0.024	15 (9, 23)	18 (12, 26)	0.000	1.50	[-0.28, 3.27]	0.90	0.098
Squat (repetitions completed)	36 (31, 40)	38 (31, 43)	0.001	35 (30, 40)	42 (34, 49)	0.000	3.45	[1.64, 5.26]	0.92	0.000
Resistance Training Skills Score	21 (18, 23)	22 (20, 25)	0.000	20 (18, 23)	23 (21, 25)	0.000	0.84	[0.28, 1.41]	0.29	0.003
BREQ Score	21 (16, 26)	20 (15, 26)	0.190	21 (17, 26)	21 (17, 26)	0.277	1.67	[-0.36, 2.69]	0.78	0.134
HIIT Self-Efficacy Score	35 (27, 45)	36 (24, 47)	0.569	38 (27, 46)	43 (32, 52)	0.000	5.70	[3.37, 7.97]	1.17	0.000
International Fitness Scale Score	17.1 ± 3.1	16.9 ± 3.6	0.257	16.6 ± 3.4	17.0 ± 3.5	0.019	0.65	[0.04, 1.25]	0.31	0.035

Notes:

SDQ = Strengths and Difficulties Questionnaire; PACER = Progressive Aerobic Cardiovascular Endurance Run; BREQ = Behavioural Regulations in Exercise Questionnaire

*I did try but that to me is like, that's not my go to, that's not my culture. And I think that's quite ... foreign.*

For the limited number of student participants who specifically recalled the use of the narratives, generally, enjoyment was expressed:

*That was cool, and the way [the teacher] put it you were like in the story you were like climbing the mountain.*

A minority of student participants expressed disengagement:

*I didn't get the point of putting a story into fitness.*

## Discussion

In this single blinded C-RCT of HIIT compared to standard PE for 11–13-year-old students, we found there was no improvement of SDQ scores or mental wellbeing in either condition. Physical fitness component improvements were generally greater for the HIIT group, and TMT scores improved significantly in both groups. Teachers did not regularly use mātauranga Māori (Indigenous knowledge) components. The study is one of the first to investigate the effects of HIIT on mental health among 11–13-year-olds, and the first to investigate the inclusion of mātauranga options in HIIT delivered in school, so these findings are of interest.

There are known small effects of HIIT on mental health in youth<sup>14</sup> and a small-to-medium positive association between physical fitness and overall mental health in youth.<sup>39</sup> Our finding of no effect for SDQ scores or mental wellbeing are contrary to the hypothesis that improving physical fitness is related to improving mental health, irrespective of exercise modality. Harris et al.<sup>16</sup> utilised a similar intervention to the present (excluded mātauranga components) and reported a small but significant intervention effect on SDQ score, albeit in a small sample (N=84), but there was no intervention effect on mental wellbeing score. Costigan et al.<sup>15</sup> also reported small but insignificant improvements in psychological wellbeing (Flourishing Scale) for two different HIIT formats delivered in school by a research team over eight weeks to adolescents aged 14–16 yrs. The authors speculated that improvements in muscular fitness might mediate improvements in wellbeing, but there was no difference between a group using a resistance training format compared to a predominantly aerobic training group.

There was no intervention effect for psychological distress (Kessler Psychological Distress Scale). Our findings were not dissimilar, in that we observed significant improvements in physical fitness generally, but no effect on wellbeing or psychological distress. It's conceivable that effects may not be apparent in a cohort whose baseline scores indicate general wellness and lack of psychological distress. Consistent with this concept, Lubans et al.<sup>40</sup> investigated the effects of school-based HIIT on older adolescents. No effect on mental health occurred overall, but effects for those who were overweight or obese at baseline and those with poor mental health were noted, particularly for internalising problems.

To our knowledge, this is the first HIIT intervention to utilise mātauranga Māori narratives, and perhaps one of the first to integrate Indigenous narratives in HIIT. Mātauranga Māori is inclusive in the education curriculum in New Zealand and has been an integral component in PE, for example, in the form of traditional Māori games and practices.<sup>41</sup> All but one teacher stated that they did not frequently use the mātauranga options, owing to the perceived extra time needed for preparation and their lack of confidence. Consistent with this, student participants provided few comments regarding the use of mātauranga in HIIT. Further investigation on such an approach should consider greater support for implementation, such as more training provision, and a resource inclusive of more detailed information. We did not include specific measures relating to Māori student health specifically, or cultural identity; these aspects could be considered in future research.

Null findings are important. The findings here could suggest that HIIT delivered in schools for this cohort and in this way is not effective for the aspects of mental health with the outcome measures we used. There are study factors that should be considered, for example, the self-report questionnaires may not have been sufficiently sensitive, or well-comprehended by this cohort, although other research using different assessments has also found no effect. Additionally, we randomised within schools so it's conceivable there was contamination between intervention and control class teachers, resulting in control teachers increasing general PE class intensity. We did not specifically measure the intensity of the control condition, and this should be

considered in future research.

Emotional distress and wellbeing are multi-determined with weak predictive power of multiple factors and complexity for testing;<sup>42</sup> genetic risks, adverse childhood experiences, inequality and social exclusion, family relationships, school success, bullying, personality and cognitive style and physiological factors including exercise, sleep and nutrition are all known influences.<sup>42</sup> Perhaps delivering brief HIIT twice weekly as an exclusive intervention approach may not be sufficient to impact on mental health, although there were effects on physical fitness outcomes, and these are known to be of benefit for general health in the longer term.<sup>43</sup>

Strengths of this study include the assessor-blinded C-RCT design, the originality of incorporating Indigenous narrative options for HIIT sessions, and the recruitment of lower socioeconomic area schools. Limitations were that we were not able to quantify the PA intensity generally experienced in the control PE group, and that both intervention and control class groups were within the same school, leading to potential indirect contamination.

## Conclusions

We found no effect of teacher-delivered brief HIIT compared to standard PE classes on 11–13-year-olds' mental health and wellbeing, as assessed by the SDQ scores and Warwick-Edinburgh Wellbeing score, despite improvements in physical fitness. Our findings add to the body of evidence on the effects of real-world HIIT delivered in a school setting on mental health with an understanding that this particular intervention was of no influence on these outcome measures; neither was standard PE. Future research should continue to explore opportunities to improve mental wellbeing via physical activity, but HIIT in 11–13 years old should not be implemented as a universal intervention for mental health gains alone.

We also determined that teachers, although initially expressing genuine enthusiasm for the concept of including mātauranga Māori in HIIT sessions, did not then utilise provided options with any regularity. Further research on the use of Indigenous narratives to underpin HIIT sessions is needed that is considerate of greater support for teachers to confidently and regularly use such an approach.

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## Trial registration

Prospectively registered 28 February 2018; Australian New Zealand Clinical Trials Registry ACTRN12618000301268.

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## Supporting Information

Additional supporting information may be found in the online version of this article:

**Supplementary File 1:** Impact of high-intensity interval training including Indigenous narratives on adolescents' mental health: a cluster-randomised controlled trial.