

Manuscript title: Effects of a four-week touch rugby and self-paced interval running intervention on health markers in active young men.

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Abstract Word Count: 250

Word Count: 4304

Figure: 1

Tables: 2

Abstract

Background: Modified team sport activity has been proposed as effective exercise modality for promoting markers of health that are comparable or greater than continuous forms of activity. However, research using modified team sports is currently limited to sedentary populations using 2-3 sessions across a minimum of 8 weeks.

Aim: To investigate the effects of a four-week touch rugby and self-paced interval running intervention on a range of health markers in active men.

Methods: Sixteen participants (age 26.4 ± 6.4 years) were matched for age, demographic and physical activity before completing a single touch rugby ($n = 8$) or running ($n = 8$) session per week for four weeks. Measures of systolic and diastolic blood pressure, resting heart rate (RHR), body composition and biochemical status were recorded pre- and post-intervention.

Results: ANCOVA analysis revealed between-group differences for impedance ($P = 0.027$), fat mass ($P = 0.008$), percentage body fat ($P = 0.008$) and fat free mass ($P = 0.002$), with greater changes after touch rugby. Systolic blood pressure decreased for both groups with greater reductions observed after touch rugby ($P = 0.002$). No between-group difference was observed for RHR, interleukin-6 or C-reactive protein ($P > 0.05$). Contrasting internal, external and perceptual loads were observed.

Conclusion: The results of this study suggest that a single session of touch rugby over a 4-week period elicited greater improvements in body composition and SBP than self-paced running, with both equally beneficial for improving RHR, diastolic blood pressure and improved inflammatory status in active young men.

Keywords: team sports, physical activity, inflammation, body composition, micro-technology

Introduction

Regular physical activity (PA) has been advocated as an important prevention strategy against the development of non-communicable diseases (NCDs) [1, 2, 3]. To date, much of literature has focused on continuous aerobic-based training such as walking, jogging or cycling [2, 4], high-intensity intermittent training [5] or sporting activities [6]. The use of modified team-sport activity, which refers to well-recognised sports that have been adapted (i.e. player numbers, pitch size, rules and duration), are reported to be successful for promoting physical activity and reducing the risk of NCDs, particularly in those unresponsive to health-based interventions [7].

Recently, the Rugby Football League introduced a touch rugby programme aimed to promote PA in those often regarded as “hard-to-reach”, including young-to-middle-aged males and females situated within low socio-economic areas of the UK. The efficacy of modified team-sports for improving health has been explored in untrained elderly men (65-75 years) [8], homeless men [9], middle-aged males and females [10, 11], and those clinically diagnosed with diabetes [12] and prostate cancer [13]. It is possible that being associated with traditional sports, recognisable, linked to professional clubs and, for those participating, feeling part of a team, developing friendships and experiencing enjoyment [14], might explain why modified team sports could be appealing for some populations.

Typically, interventions using modified team-sports have lasted between 8 and 24 weeks, indicating a dose-response relationship between duration and the magnitude of change in routine measures of health [1, 8, 15, 16]. For example, Krustup et al. [15] reported reductions in systolic (SBP), diastolic (DBP) blood pressure of 2.0 and 1.0 mmHg, respectively after 4 weeks of modified team-sport (soccer); while after 12 weeks, reductions of 8.0 and 5.0 mmHg were observed. Similarly, RHR was 3 $\text{b}\cdot\text{min}^{-1}$ after 4 weeks and 6 $\text{b}\cdot\text{min}^{-1}$ after 12 in untrained men. Modified team-sports are also effective at improving body composition through reductions in body mass (-0.2 to -5.4%), fat mass (FM) (-2.9 to -13.6%) and percentage body fat (%BF) (-2.1 to -11.7%), as well as increasing lean body mass (0.4-5.9%) and lower-limb bone mineral content (0.86-3.2%) [11, 12, 15-17]. Such changes in body composition might also impact on chronic low-grade systemic inflammatory status, which refers to a prolonged elevation in concentrations of circulating cytokines, acute phase proteins and adhesion molecules [18, 19]. Indeed, it has been reported that approximately 30% of circulating IL-6 is released from adipose tissue, and acts as a major regulator of the hepatic acute-phase protein response and activation of CRP gene expression [20]. Mendham et al. [11] reported reductions in FM (2.9%) and %BF (3.7%) alongside contemporaneous reductions in concentrations of IL-6 (2.05 ± 0.79 cf. 1.35 ± 0.43 $\text{pg}\cdot\text{mL}^{-1}$) and CRP (2.90 ± 0.59 cf. 2.45 ± 0.59 $\text{mg}\cdot\text{L}^{-1}$) after 8 weeks of modified team-sport activity. Similarly, Donges et al. [21] reported a reduction in %BF

after 12-weeks of aerobic- and resistance-based training, which was accompanied by reductions in IL-6 concentration. In contrast, Mendham et al. [1] observed no change in IL-6 or CRP concentrations after 12-weeks of modified team-sport (rugby) activity within an Indigenous Australian population who demonstrated clinical risk factors for type 2 diabetes mellitus. As such, further research is required to understand the effects of modified team-sports on inflammatory status.

Much of the research to date has focused on sedentary and/or diseased populations, where the introduction of PA is likely to have a positive outcome on measures of health. However, with a proportion (~35%) of the general population in Europe not sufficiently active to meet current recommendations (150 minutes of moderate activity per week) [22], it is unknown if the addition of modified team-sport to other forms of PA provides any additional benefit. To date, only one study has explored the effects of modified team-sport using a habitually active population although the participants presented with symptoms of hypertension [23]. Additionally, much of the literature has focused on modified team-sports utilising soccer that required the participant to be active for the full session. Sports such as touch rugby that allow unlimited and self-initiated interchanges, might be perceived more favourably by participants enabling them to rest between bouts of activity. It was noted by Parfitt, Rose and Burgess [24] that allowing participant to select their intensity rather than be prescribed resulted in positive affective response to exercise, which likely improves the chance of continued participation [25]. Whilst the intensity cannot be fully controlled during touch rugby, the unlimited and self-initiated interchanges might reduce the overall perceived exertion. Finally, many of the reported interventions include two or more sessions per week over 12 weeks or more, which is subsequently reduced (1.3 *cf.* 2.4 session per week) over a prolonged period [15]. Despite this reduction in training load, body composition, cardiovascular function and some biochemical measures remained improved compared to baseline at 64 weeks. To date, only one study has reported that playing modified team-sport (touch rugby) once per week over a 12-week period was beneficial for promoting health [26]. Whilst once per week is more likely to be adhered to compared to 2-3 sessions per week, further research is required to determine if once per week over a short intervention period provides any benefit when combined with habitual activity.

Accordingly, the purpose of this study was 1) to assess the effectiveness of touch rugby and interval running for promoting positive changes in blood pressure, RHR, body composition and pro-inflammatory cytokines and 2) to determine if these modes of exercise performed once per week over a 4-week period was sufficient to induce a positive change in health markers in already active participants.

Methods

Participants

With institutional ethics approval and informed consent, sixteen recreationally active men (mean \pm SD: age 26.4 \pm 6.4 years, stature 178.7 \pm 7.0 cm) volunteered to participate. At the time of the study (June/August), all participants were residing in the North West of England and, in the preceding 6 months, reported via a PA questionnaire that they were completing 2 to 4 sessions of activity per week lasting between 30 and 60 minutes with the maximal combined PA of 3 x 45 minutes. Activities varied between participants, but typically included resistance training, cycling, running, circuit training and martial arts. All participants stated they were non-smokers, taking no medication and were free of any injuries or pre-existing cardiovascular, inflammatory or metabolic disorders. An a-priori power calculation was performed (G*Power 3.1) based on the work of Reddy et al. [27] with power at 0.80 and alpha at 0.05. Using the results for SBP as the dependent variable, the partial eta squared, determined from the F ratio and sample size was 0.43, resulting in a required sample of 8 participants per group and is in agreement with previous research [28].

Research design

Participants were matched for age and physical activity (over last 6 months) and non-randomly assigned to a touch rugby ($n = 8$) or self-paced interval running ($n = 8$) group. All participants in the touch rugby group were recruited through the Play Touch Rugby League programme by the organisers and had prior experience (1-5 years) of the sport, whilst the running group were recruited via quota sampling (based on aforementioned criteria) from the general population. Both groups completed a four-week intervention with anthropometric, physiological and biochemical measures taken before and after the intervention period. The internal, external and perceptual loads were recorded for all exercise sessions. Participants were asked to maintain their normal physical activity levels and dietary intake which was verbally confirmed each week. Participants were required to have completed no physical activity for 48 hours before, consumed no alcohol 24 hours before and no caffeine in the 12 hours before the pre- and post-intervention assessments.

Habitual physical activity

Participant's physical activity frequency, duration, perceived intensity and type of activity were recorded using a questionnaire, with frequency determined as the absolute number of sessions, duration to the nearest quarter of an hour and perceived intensity using the following descriptors and examples: light (e.g. walking slowly or light

stretching), moderate (e.g. walking briskly or swimming with moderate effort) and high (e.g. heavy resistance work).

Experimental trials

The touch rugby intervention consisted of a single 45-minute match performed once a week for the 4-week period. The game consisted of six-a-side, non-contact rugby on a natural grass (width: 40 m; length 60 m) pitch and adopted an unlimited interchange rule [29] with the game being played across 2 x 20-minute halves interspersed with a 5-minute rest period. All touch rugby sessions were performed on the same day of the week at the same time (19:00). Touch rugby was played with standard Touch rules whereby each team had six 'plays' whilst in possession of the ball where each 'play' was concluded upon being touched by an opponent. After a successful touch, the attacking team completed a 'play the ball' which involved rolling the ball backwards before a teammate retrieved the ball and passed backwards to an 'on side' player. During the 'play the ball', the defending team had to retreat 5 m before advancing to make the next touch. At the end of six unsuccessful touches or if a try was scored, the ball was turned over to the other team.

The running intervention was performed once per week and completed individually with the participant running around the perimeter of a 91 x 120 m natural grass pitch for 2 x 20-minute periods with 5 minutes rest between. Participants were instructed to regulate and self-adjust their speed to cover the greatest distance possible whilst ensuring they continued to run for the full duration. All participants were not aware of the time that had elapsed during each session, nor was information on the internal or external demands disclosed until after the intervention period. Participants in the running group were free to choose an appropriate day and time in week 1 which was kept the same throughout the intervention period.

Physical measurements

Anthropometry and body composition

Stature was measured to the nearest millimetre (mm) using a portable stadiometer (SECA, Leicester Height Measure, Hamburg, United Kingdom) and body mass measured to the nearest 0.1 kg using a calibrated electronic scale (SECA 813, SECA, Hamburg Germany). Bioelectrical impedance was measured directly using a tetra-polar device (Bodystat, 1500, Bodystat, Douglas, Isle of Man) and used to predict %BF, FM and fat free mass (FFM). Participants were instructed to attend euhydrated, which was confirmed by the participants on arrival, and rested in a supine position for 10 minutes before two injector electrodes and two detector electrodes were placed on the right hand and foot. This method is deemed to be reliable for measuring FFM ($r = 0.998$, mean bias = 0.0 kg, 95%

limits of agreement (LoA) = -1.0 to 1.0 kg) [30] and percentage body fat ($r = 0.876$, mean bias = 1.41 %, 95% LoA = 8.34 %) [31].

Blood pressure and resting heart rate

After 10 minutes' rest in a seated position, SBP and DBP were measured manually using an aneroid sphygmomanometer (WelchAllyn, Durashock Handheld Aneroid, Cachan, France) and stethoscope (Littmann, Select, 3M Health Care, Neuss, Germany) to the nearest mmHg. Simultaneously, RHR was measured using a heart rate monitor (Polar Electro, FS1, Polar Electro, Oy Finland), with the lowest value obtained during a 1-minute period used for analysis [32].

Blood sampling

After 20 minutes' rest in a seated position, a 10 mL sample was obtained from the median cubital vein and placed into vacutainers (BD) containing di-potassium ethylene diamine tetra-acetic acid. Once separated from whole blood, plasma was analysed in duplicate to determine concentrations of circulating CRP and serum IL-6 using an enzyme-linked immunosorbent assay (ELISA; Quantikine High Sensitivity, R&D Systems, Minneapolis, USA). The optical density for CRP and IL-6 were measured using a microplate reader (Biochrom EZ Read 400, Biochrom, Cambridge, UK) at wave lengths of 570 nm and 450 nm, respectively. CRP and IL-6 were measured with an inter- and intra-coefficient of variation of between 3.8% to 7.0% and 1.6% to 3.4%, respectively.

Internal, external and perceptual responses

Fifteen minutes before each session a 10 Hz microtechnology device fitted with a 100 Hz tri-axial accelerometer, gyroscope and magnetometer (Catapult, OptimEye S5, Catapult Innovations, Scoresby, Australia) was activated and positioned in a custom-made harness positioned between the scapulae. The mean number of satellites and HDOP were 15.2 ± 3.8 and 0.7 ± 0.1 for all sessions, respectively. Participants wore the same unit for all sessions. Data was recorded and analysed (Catapult Sprint version 5.1.4) for total, low- ($<9.0 \text{ km} \cdot \text{h}^{-1}$), moderate- ($9.1\text{-}13.0 \text{ km} \cdot \text{h}^{-1}$) and high-intensity distance as previously used with a similar population [33]. Mean velocity was determined for the full duration, and peak velocity was defined as the highest speed recorded during the session. Time spent above $20 \text{ W} \cdot \text{kg}^{-1}$, PlayerLoad™ and distance covered at pre-set acceleration thresholds were measured. Mean (HR_{mean}) and peak (HR_{peak}) heart rate were also recorded using a heart rate monitor (Polar Electro, Finland, Oy) and recorded on the microtechnology device.

Immediately after the session, participants completed the Subjective Exercise Experience Scale, which was used to assess the participants' sense of positive well-being, psychological distress and fatigue [34]. In addition, participants individually provided a rating of perceived exertion using Borg's CR-10 scale [35] 10 minutes after each session and was multiplied by exercise duration to provide a global measure of training load [36].

Statistical analysis

Data are presented as mean and standard deviation. All dependent variables were assessed for normal distribution using the Shapiro-Wilk test. Difference in baseline values between groups for anthropometric, body composition, physiological and biochemical markers of health were investigated using an independent samples *t*-test. Whilst baseline values for each measure were not statically different, to control for the mean between-group difference at baseline, a one-factor analysis of covariance (ANCOVA) was used with the pre-to-post change as the dependent variable, intervention (i.e. touch rugby or running) as an independent variable and baseline values as a covariate. Cohens effect size was calculated from the partial eta squared result. Within-group, pre-to-post changes were assessed using a paired sample *t*-test. Independent sample *t*-tests were used to compare the internal and external demands between interventions. Perceptual measure and previous physical activity were assessed using a Mann Whitney-U test due to the level of measurement and non-normal distribution. In all cases, alpha was set at $P < 0.05$. Furthermore, to provide an interpretation of the magnitude of change, effect sizes accompanied all inferential statistics and were calculated as the difference between trials divided by the pooled SD and the following were applied: 0.0-0.2, *trivial*; 0.2-0.6, *small*; 0.6-1.2, *moderate*; 1.2-2.0, *large*; >2.0, *very large* [37]. All inferential statistics was performed using IBM SPSS (Version 26) for Macintosh.

Results

Differences in the combined frequency and duration in the preceding 6 months was not different between the touch rugby ($133 \pm 14 \text{ min} \cdot \text{wk}^{-1}$) and running ($133 \pm 21 \text{ min} \cdot \text{wk}^{-1}$) groups ($Z = -0.462, P = 0.644$). In all instances, participants perceived their intensity to be light-to-moderate. The average combined frequency and duration (touch rugby = $130 \pm 11 \text{ min} \cdot \text{wk}^{-1}$; running = $130 \pm 24 \text{ min} \cdot \text{wk}^{-1}$) during the intervention period (excluding the intervention) was not different between groups ($Z = -0.427, P = 0.669$), nor was it different to that reported during the preceding 6-month period (touch rugby, $Z = -0.552, P = 0.581$; running, $Z = -0.557, P = 0.577$).

Insert Table 1 Here

There was no statistical difference in baseline values between the touch rugby and running group, though small mean differences were evident. The pre- and post-intervention change in body mass was not different between groups ($F = 0.711$, $P = 0.414$) nor was there any within-group change (touch rugby = $t = -0.694$, $P = 0.510$; running = $t = 0.467$, $P = 0.655$). Impedance indicated a between-group difference ($F = 6.228$, $P = 0.027$), with a change observed for the touch rugby group ($t = 4.806$, $P = 0.002$) but not the running group ($t = 0.817$, $P = 0.441$). Between-group analysis revealed differences in FM ($F = 9.981$, $P = 0.008$) and %BF ($F = 9.936$, $P = 0.008$) with greater reductions in the touch rugby group (FM, $t = 4.708$, $P = 0.002$; %BF, $t = 5.091$, $P = 0.001$) compared to the running group (FM, $t = 0.917$, $P = 0.390$; %BF, $t = 0.230$, $P = 0.824$). The change in FFM was different between groups ($F = 14.673$, $P = 0.002$) and within-group analysis revealed increases after the touch rugby ($t = 3.778$, $P = 0.007$) intervention but not running ($t = 1.295$, $P = 0.236$).

No between-group difference was observed for changes in RHR ($F = 0.165$, $P = 0.692$) or DBP ($F = 2.791$, $P = 0.119$), but a statistical difference was evident for SBP ($F = 6.748$, $P = 0.022$). The within-group change was similar for the touch rugby ($t = 4.439$, $P = 0.003$) and running ($t = 0.049$, $P = 0.049$) groups (Table 1). There was no between-group difference in the change in CRP concentration ($F = 0.530$, $P = 0.480$), though a within-group difference was observed for the running group ($t = 3.607$, $P = 0.009$; ES = -0.61 ± 0.84) but not touch rugby group ($t = 1.642$, $P = 0.145$; ES = -0.33 ± 0.83) (Figure 1). No between-group difference in the change of IL-6 was observed ($F = 2.854$, $P = 0.115$), though a within-group change was observed in the touch rugby ($t = 4.640$, $P = 0.002$; ES = -1.32 ± 0.91) and running group ($t = 2.379$, $P = 0.049$; ES = -0.75 ± 0.85) (Figure 1).

*** Insert Figure 1 Here***

Between-group differences in measures of external, internal and perceptual training load as well as positive well-being, psychological distress and feeling of fatigue are presented in Table 2.

*** Insert Table 2 Here***

Discussion

This study investigated the effectiveness of a short intervention consisting of touch rugby or self-paced interval running for improving markers of health in an active group of young men. The main finding was that 4 weeks of touch rugby and interval running, in addition to their habitual activity, resulted in a marked reduction in SBP, whilst the touch intervention appeared more effective for reducing FM and %BF as well as increasing FFM.

Markers of low-grade systemic inflammation were, on average, reduced over the intervention period, with no between-group difference observed. The external and internal demands differed between interventions, with touch rugby eliciting greater high-intensity running, peak velocity, time above $20 \text{ W}\cdot\text{kg}^{-1}$, accelerated running and feeling of positive well-being compared to self-paced interval running. In contrast, the self-paced running group covered greater total- low-intensity and moderate-intensity running and demonstrated higher internal and perceptual loads.

Both interventions appeared effective at reducing FM after only 4-weeks (touch, -2.8 kg ; running, -0.4 kg). This finding reaffirms similar reductions after 12-weeks of modified team-sport (soccer) (-2.7 kg) and steady-state running (-1.8 kg) [15] and 8-weeks modified team-sport (touch rugby) (-0.7 kg) and cycling (-0.8 kg) [2]. Our results suggest that touch rugby was more effective for reducing FM and %BF compared to running when controlling for baseline differences, which is likely explained by the different external loads imposed by the respective interventions. For example, the touch group covered more high-intensity running, time above $20 \text{ W}\cdot\text{kg}^{-1}$ and distance at the higher acceleration thresholds when compared to the interval running group and may have resulted in a greater energy expenditure [38]. This notwithstanding, both groups appeared to induce positive changes in FM and %BF, suggesting that one 45-minute high-intensity activity in addition to their habitual activity was beneficial for improving body composition.

In contrast to the running group, an increase in FFM was observed for the touch rugby group, supporting the findings of Mendham et al. [11] who reported a 1.1 kg increase in FFM after 8 weeks of touch rugby in sedentary middle-aged men. Whilst the increase observed after touch rugby was of greater magnitude than that reported by Mendham et al. [11] and might be due to the activity levels of the participants both before and during the intervention period as well as differences in methods. Mendham et al. [11] used dual-energy X-ray absorptiometry (DEXA), which is regarded as an accurate, non-invasive technique for assessing body composition [39]. However, due to the cost and expertise required associated with DEXA, this study used bioelectrical impedance, which provides a doubly indirect assessment. Notwithstanding these differences, our results support the notion that the movement demands associated with modified team-sports are important for eliciting positive changes in estimates of FFM [2, 10, 11, 17]. The running group experienced no meaningful change in FFM, which confirms similar observations by Krstrup et al. [15] after 12-weeks of running. These results suggest that greater time above $20 \text{ W}\cdot\text{kg}^{-1}$ and number of accelerations and decelerations, which are indicative of high mechanics loading, appears important for promoting FFM [10].

The reduction in SBP after 4-weeks of touch rugby and running (-5.5 mmHg and -2.0 mmHg, respectively) are of sufficient magnitude to be clinically meaningful [40] and concur with similar values reported after 12 and 24 weeks of modified team sport (soccer) in untrained [15] and diabetic men [13], respectively. Controlling for baseline difference, it appeared the touch intervention was more effective for lowering SBP while no between-group difference was apparent for DBP. Resting heart rate was lower after both the touch rugby (-4 b·min⁻¹) and running (-3 b·min⁻¹) interventions and was similar in magnitude to that reported previously in sedentary and untrained adults (~3-6 b·min⁻¹) [15, 26]. While it is important to note that the change between groups was not different, the within-group change revealed a *small* effect size for both groups and might be indicative of a reduction in sympathetic outflow, vasoconstrictor state of the peripheral vasculature and vascular remodelling [10, 15, 41]. Whilst this supports previous research, it is important to acknowledge that the change observed was within the reported day-to-day variability (3-4 b·min⁻¹) of RHR [42] and that further research is required to confirm these findings after a short-term intervention.

Previous research has reported reductions in IL-6 and CRP amongst other pro- and anti-inflammatory cytokines after a period of modified team-sport activity [1, 21] with agreeing with these findings after four weeks of touch rugby and self-paced interval running. Both interventions demonstrated a reduction in IL-6 after 4 weeks of training whereas CRP was highly variable with a within-group change only observed after the running intervention. Mendham et al. [11] observed a reduction in IL-6 and CRP after 8 weeks of touch rugby in sedentary middle-aged men, which was accompanied by a concomitant reduction in FM and %BF. Furthermore, Mendham et al. [1] observed a reduction in CRP after 12 weeks of multi-sport activity despite no change in IL-6 over the same period. It is, however, important to note that the participants used in the latter study were clinically obese and presented clinical risk factors for diabetes. Our results support the notion that modified team sports might be effective for reducing IL-6 though it is possible that four weeks was not sufficient for some individuals and that longer intervention period is required to detect changes in CRP that exceed the reliability (coefficient of variation = 3.8-7.0%).

Touch rugby elicited a lower rating of perceived exertion compared to the running group, which might be important when concerning exercise adherence [43]. Though not statistically different, our results for perceived well-being, fatigue and psychological distress support those of Mendham et al. [44] who reported participation in touch rugby was perceived to be less challenging (6.6 ± 2.0 cf. 7.4 ± 1.8 AU) and more 'fun' (6.6 ± 0.5 cf. 5.2 ± 1.3 AU) when compared to cycle ergometry. These findings are important when considering modified team-sports as a long-term health promotion activity. For example, sport such as touch rugby, which allow multiple

interchanges, are likely to result in a reduced perceived exertion and greater positive affective responses to exercise, thus strengthening the intentions for continued participation [25].

Despite our results showing that the addition of one touch rugby or self-paced running session per week can improve the health of active men, this study is not without its limitations. Firstly, it is important to note that the sample size included was based on a single dependent variable and that the results for others might be underpowered and therefore caution should be taken when interpreting those with a low observed power. Secondly, a control group was not included within the study design and therefore it is unknown if either intervention was beneficial compared to habitual activity alone. Further, the participants were not randomly allocated to a training group, which has important implication due to the risk of selection bias and more specifically, inclusive bias with reference to the PTRL group. As such, whether these findings can be extrapolated to other groups or a wider population remains unknown. Whilst the lack of randomisation is problematic, we did match the groups and the statistical approach used would account for any initial mean baseline differences between groups. Finally, our analysis was limited to two key markers of inflammation and as such, future research might wish to investigate additional markers of chronic low-grade systemic inflammation such as TNF- α and IL-18.

Conclusion

Our results reaffirm that participation in a modified team-sport and self-paced running is beneficial for promoting measures of health when combined with their habitual activity. The external demands associated with the touch rugby intervention indicated that greater vigorous activity and distance accelerating at higher thresholds was performed and might be important for responsible for the greater changes in SBP and body composition when compared to self-paced running. Further, as touch rugby allows self-selected and unlimited interchanges, it might sever promote sustained participation due to the lower rating of perceived exertion and fatigue as well as greater positive well-being compared to self-paced interval running. Overall, the results of this study demonstrate that one additional session per week of touch rugby or interval running was sufficient in promoting a number of health measures in young men who were active but not meeting current physical activity guidelines.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no competing interests.

Ethical approval: This research was approved by the Faculty of Life Sciences Ethics Committee at the University of Chester (Ref No. 1010/15/ND/SES)

Informed consent Written consent was obtained from all participants.

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Figure 1. Fasting blood chemistry of inflammatory cytokines, interleukin-6 (top panel) and C-reactive protein (bottom panel) before and after 4-weeks of touch rugby and self-paced interval running. * Within-group change ($P < 0.05$).

Table 1. Body composition and physiological measures in active men, before and after 4 weeks of touch rugby and self-paced interval running

* Within-group change ($P < 0.05$). FM = fat mass; FFM = fat free mass; BF = percentage body fat; RHR = resting heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure.

Table 2. External, internal and perceptual responses during the touch rugby and running.

* Within-group change ($P < 0.05$). ES = effect size. %HR_{peak} = percentage of peak heart rate. sRPE = session rating of perceived exertion. AU = arbitrary units.