

ORIGINAL RESEARCH

THE CARDIOVASCULAR AND METABOLIC RESPONSES TO ULTIMATE FRISBEE IN HEALTHY ADULTS

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ABSTRACT

Introduction: Physical activity has been linked to a plethora of associated health outcomes; however, the majority of Americans are not engaging in enough activity to meet the minimum guidelines. Ultimate Frisbee may serve as an alternate to more traditional physical activity modalities. The purpose of this study was (a) to assess the cardiovascular and metabolic responses to Ultimate Frisbee and (b) to determine if Ultimate Frisbee meets current guidelines for improving and maintaining cardiorespiratory fitness.

Methods: Sixteen men and women (mean \pm SD: age, height, weight, body composition, and $VO_{2max} = 21.4 \pm 1.3$ years, 175.3 ± 8.6 cm, 66.0 ± 8.6 kg, 8.8 ± 5.3 %, and 57.1 ± 7.3 mL/kg/min, respectively) completed both a maximal graded exercise test and 20-min simulated Ultimate Frisbee match on non-consecutive days. Cardiovascular and metabolic data were collected via a portable calorimetric measurement system.

Results: Overall heart rate for the 20-min Ultimate Frisbee simulated match was 148.1 ± 15.4 beats/min, which corresponded to $65.3 \pm 11.6\%$ HRR. Exercise intensity in METs was 9.5 ± 1.6 , which equated to $61.2 \pm 11.6\%$ VO_{2R} . Total energy expenditure for a simulated Ultimate Frisbee match was 1994.9 ± 545.6 kJ/match.

Conclusions: Results indicate that Ultimate Frisbee is a feasible alternative to more traditional aerobic exercise modalities for healthy adults that fulfills guidelines for improving and maintaining cardiorespiratory fitness.

Key Words: Energy Expenditure, Exercise Intensity, Team Sport, Outdoor Physical Activity

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INTRODUCTION

It is well appreciated that regular physical activity confers a myriad of health benefits, including the prevention of various chronic diseases such as hypertension, obesity, Type 2 diabetes, dyslipidemia, and cardiovascular disease. Accordingly, numerous health and fitness organisations including the American Council on Exercise and the American College of Sports Medicine (ACSM), promote regular physical activity with the consensus statement calling for a minimum of 30 minutes moderate-intensity aerobic exercise on 5 days each week (or 150 minutes) or vigorous-intensity aerobic exercise for a minimum of 25 minutes on 3 days each week (or 75 minutes) or an equivalent combination of both¹⁻⁴. Additionally, the ACSM has recommended a target energy expenditure of 627.6 to 1673.6 kilojoules per day (kJ/day). Nevertheless, according to 2013 data in adults ≥ 18 years the age-adjusted proportion who reported engaging in moderate or vigorous physical activity that met current physical activity guidelines for Americans was 50.0%⁵. This is perhaps due in part to a lack of enjoyment experienced from participation in traditional forms of physical activity (such as walking, running, swimming, and cycling). One possible way in which to increase the number of individuals involved in regular physical activity is to emphasise that the health benefits of traditional exercise can often be found in alternative forms of exercise.

Ultimate Frisbee is a game that originated in the 1960s. It involves two teams whose players attempt to toss a Frisbee to one another until they cross the opponent's goal. Possession changes hands when the Frisbee is intercepted or touches the ground or goes out of bounds. Ultimate Frisbee may be played in both pickup games and competitive organised leagues. An Ultimate Frisbee match consists of four 10-minute quarters under professional rules. Ultimate Frisbee is a worldwide sport now played in over 50 countries that has been increasing in popularity⁶. Indeed, the Sports & Fitness Industry Association continues to report Ultimate Frisbee as one of the fastest growing team sports in the United States⁷. As of 2012⁸ it was estimated that

there were 5.1 million Ultimate Frisbee players in the United States alone. One of the reasons offered for the increased popularity of Ultimate Frisbee is that it is fun. Given that lack of enjoyment is frequently offered as one of the reasons for physical inactivity, the 'fun factor' associated with Ultimate Frisbee increases the likelihood of a lifetime pursuit of physical activity. Nevertheless, to our knowledge there is no research examining the physiological responses to Ultimate Frisbee. Therefore, the purpose of this study was (a) to assess the cardiovascular and metabolic responses to Ultimate Frisbee and (b) to determine if Ultimate Frisbee meets current guidelines for improving and maintaining cardiorespiratory fitness.

METHODS

Participants

16 healthy and physically active young adults (18 to 25 years of age) were recruited from the student population of a local university, as well as the surrounding community, via advertisement through the university website, local community newspaper, and word-of-mouth. Participants were eligible for inclusion into the study if they were low risk and physically active as defined by the ACSM⁴. Exclusionary criteria included evidence of cardiovascular pulmonary, and/or metabolic disease. This study was approved by the Human Research Committee at Western State Colorado University. Prior to participation, each participant signed an informed consent form and underwent baseline testing. The physical and physiological characteristics of participants are presented in Table 1.

Experimental Design

All measurements were obtained on non-consecutive testing days. Day 1 consisted of the collection of individual physical and physiological measures and measurement of resting metabolic rate and the maximal graded exercise test. Day 2 consisted of assessment of the cardiovascular and metabolic responses to a simulated Ultimate Frisbee match. Testing sessions were separated by 2 to 20 days.

Table 1. Physical and physiological characteristics of the participants.

Parameter	Women (N=4)	Men (N=12)	Combined (N=16)
Age (years)	20.8 ± 1.0	21.6 ± 1.3	21.4 ± 1.3
Height (cm)	163.3 ± 5.1*	179.3 ± 4.9	175.3 ± 8.6
Weight (kg)	59.0 ± 4.6*	68.3 ± 8.5	66.0 ± 8.6
Body fat (%)	16.2 ± 2.3*	5.8 ± 1.9	8.8 ± 5.3
Resting heart rate (beats/min)	68.8 ± 7.4	65.1 ± 8.0	66.0 ± 7.8
Maximal heart rate (beats/min)	193.3 ± 7.2	190.7 ± 6.6	191.3 ± 6.6
Maximal oxygen uptake (mL/kg/min)	45.7 ± 1.9*	60.8 ± 3.2	57.1 ± 7.3
Resting oxygen uptake (mL/kg/min)	3.6 ± 0.1*	3.9 ± 0.2	3.8 ± 0.2

Values are mean ± SD; *denotes sex difference, $p < .05$.

Instrumentation

Resting metabolic rate and oxygen uptake during the simulated Ultimate Frisbee match and maximal graded exercise test were measured using an Oxycon Mobile (CareFusion, Yorba Linda, CA) portable calorimetric measurement system. Continuous HR measurements were obtained using a Polar F1 heart rate monitor (Polar Electro Inc., Lake Success, NY) interfaced with the Oxycon Mobile system. Additionally, a Garmin Forerunner 305 GPS (Garmin International, Inc., Olathe, KS) unit was used to record distance traveled throughout the simulated Ultimate Frisbee match.

Protocols

Physical and physiological measurements

All physical measurements were obtained using standardised guidelines⁴. Briefly, participants were weighed to the nearest 0.1 kg on a medical grade scale and measured for height to the nearest 0.5 cm using a stadiometer. Percent body fat was determined via skinfolds. Resting blood pressure was also obtained.

Resting metabolic rate and maximal exercise test

After being connected to the Oxycon Mobile system and Polar F1 heart rate monitor, participants rested quietly for 5-min in a seated position. The

last minute of breath-by-breath and heart rate (HR) data were averaged and considered to be resting metabolic rate (VO_2) and resting HR. On a power treadmill (Powerjog GX200, Maine), a modified Balke protocol, similar to previous research⁸, was performed with participants selecting a comfortable running speed that could be maintained for the duration of the test. After a 2 min warm up performed at a walking speed of 88.4 m/min, participants were gradually brought to the selected running speed for the first minute of the test, which was then maintained throughout the duration of the test. The warm up portion and first 1 min of the protocol were performed at 0% grade, thereafter, each minute the treadmill grade was increased by 1% until volitional fatigue was attained. The criteria for attainment of maximal oxygen consumption ($\text{VO}_{2\text{max}}$) was two out of three of the following: (1) a plateau ($\Delta\text{VO}_2 < 150 \text{ mL/min}$) in VO_2 with increases in workload, (2) maximal respiratory exchange ratio (RER) > 1.1 , and (3) maximal HR within 15 beats/min of the age-predicted maximum ($220 - \text{age}$).

Assessment of cardiovascular and metabolic responses to Ultimate Frisbee

Participants played a series of eight simulated (i.e., pickup) Ultimate Frisbee matches. Matches consisted of six vs. six, with each side having 1-2

reserve players. Matches consisted of 2 x 20-min halves. Each participant had their cardiovascular and metabolic responses to Ultimate Frisbee assessed during one-half of the match (i.e., 20-min). Half of (N=8) the participants had cardiovascular and metabolic responses directly measured during the first 20-min half and the other half (N=8) of participants were directly assessed during the second 20-min half. However, all participants played the entire match. The cardiovascular and metabolic assessment consisted of wearing the Oxycon Mobile portable calorimetric measurement system, the Polar Heart Rate monitor, and the Garmin Forerunner GPS for one-half of the simulated match to collect the required cardiovascular and metabolic response data. Additionally, for the final simulated match peak blood pressure was measured in all participants at the conclusion of the match. Post-match systolic blood pressure (SBP) and diastolic blood pressure (DBP) were subsequently assessed for a 90-min post-exercise timeframe in 30-min increments.

Exercise intensity and metabolic calculations

Individual heart rate reserve (HRR) was determined as the difference between resting and HR_{max} values. Percent HRR was calculated by subtracting resting HR from the Ultimate Frisbee HR response, dividing by HRR, and then multiplying the quotient by 100. Likewise, individual oxygen uptake reserve (VO_{2R}) was quantified by taking the difference between resting and maximum VO_2 values. Percent VO_{2R} was calculated by subtracting resting VO_2 from the Ultimate Frisbee VO_2 response, dividing by VO_{2R} , and then multiplying the quotient by 100. The metabolic equivalent (MET) for Ultimate Frisbee was determined by dividing the Ultimate Frisbee VO_2 by resting VO_2 . Energy expenditure (kJ/match) for the Ultimate Frisbee match was calculated by first multiplying the above-calculated MET equivalent of the Ultimate Frisbee match by individual resting VO_2 . This term was then subsequently multiplied by individual body mass, divided by 1000, multiplied by the caloric equivalent for the measured



Figure 1 – The Oxycon Mobile metabolic system attached to a participant before (left) and during an Ultimate Frisbee match (right)

respiratory exchange ratio or RER (e.g., an RER of 0.83 equates to an energy cost of 4.838 kilocalories (kcal)/L of oxygen), converted to kilojoules with a conversion factor of 4.18 kJ/kcal, and last multiplied by 40-min (duration of the simulated Ultimate Frisbee match).

Statistical analyses

All analyses were performed using SPSS Version 22.0 (Chicago, IL) and GraphPad Prism 6.0. (San Diego, CA). Primary outcome measures include relative exercise intensity [% HRR and % VO_{2R}], METs, and energy expenditure (kJ/min and kJ/match). Measures of centrality and spread are presented as mean \pm SD and range. Independent *t*-tests were used to compare physical and physiological parameters between women and men. The SBP and DBP responses over time (pre-Ultimate Frisbee match, post-Ultimate Frisbee match, 30-min, 60-min, and 90-min recovery) were analysed using a one-way repeated measures ANOVA followed by Tukey's post hoc tests, where indicated. The probability of making a Type I error was set at $p \leq .05$ for all statistical analyses.

RESULTS

Ultimate Frisbee cardiovascular and metabolic responses

Cardiovascular and metabolic responses (mean \pm SD) to the simulated Ultimate Frisbee match for the sixteen participants (4 women and 12 men) who completed the study are presented in Table 2. Overall heart rate for the 20-min simulated Ultimate

Table 2. Cardiovascular and metabolic responses to Ultimate Frisbee.

Parameter	Women (N=4)	Men (N=12)	Combined (N=16)
HR (beats/min)	147.2 ± 7.0	148.5 ± 18.8	148.1 ± 15.4
Range	104-184	86-195	86-195
%HRR	62.9 ± 8.2	66.1 ± 12.8	65.3 ± 11.6
Range	22-89	22-98	22-98
%VO ₂ R	63.8 ± 16.3	60.3 ± 10.3	61.2 ± 11.6
Range	12-99	10-96	10-99
METs	8.5 ± 2.0	9.8 ± 1.4	9.5 ± 1.6
Range	2.4-13.3	2.6-15.5	2.4-15.5
kJ/min	37.2 ± 10.0*	54.0 ± 12.9	49.8 ± 13.8
Range	9.6-56.5	13.4-87.0	9.6-87.0
kJ/match	1485.3 ± 401.7*	2164.4 ± 486.2	1994.9 ± 545.6
Range	---	---	---
Distance (km)	2.04 ± 0.16	2.20 ± 0.32	2.17 ± 0.31
Range	1.92-2.27	1.58-2.59	1.58-2.59

Values are mean ± SD. (HR, heart rate; %HRR, percentage heart rate reserve; kJ, kilojoules; km, kilometers; METs, metabolic equivalents; %VO₂R, percentage oxygen uptake reserve); *denotes sex difference, *p* < .05.

Frisbee match was 148.1 ± 15.4 beats/min, which corresponded to 65.3 ± 11.6% HRR. Exercise intensity in METs was 9.5 ± 1.6, which equated to 61.2 ± 11.6% VO₂R. Total energy expenditure for a simulated Ultimate Frisbee match was 1994.9 ± 545.6 kJ/match. Independent *t*-tests revealed no significant differences (*p* > .05) between women and men for all cardiovascular and metabolic responses with the exception of significant differences (*p* < .05) in kJ/min and kJ/match. These differences are likely explained by the fact that men were significantly (*p* < .05) heavier than women. Figure 2 illustrates the exercise intensity in terms of HRR for a representative participant throughout the duration of the Ultimate Frisbee

match.

Ultimate Frisbee blood pressure responses

One-way ANOVA indicated a significant increase (*p* < 0.05) in the post-Ultimate Frisbee match SBP relative to pre-Ultimate Frisbee match SBP (+20.0 ± 13.2 mmHg). Throughout the recovery timeframe SBP values were significantly reduced (*p* < 0.05) when compared to pre-Ultimate Frisbee match values: 30-min (-5.6 ± 5.1 mmHg), 60-min (-8.6 ± 5.0 mmHg), and 90-min (-8.7 ± 5.7 mmHg). In contrast, there were no significant changes (*p* > 0.05) in the DBP response to Ultimate Frisbee over time.

DISCUSSION

The main finding of the present study is that participation in a simulated Ultimate Frisbee match in young adults elicits cardiovascular and metabolic responses that fulfill exercise intensity guidelines for improving and maintaining cardiorespiratory fitness^{2,4}. Mean exercise intensity was 65.3% of HRR, 61.2% of VO₂R, and 9.5 METs, respectively. Overall energy expenditure for Ultimate Frisbee was ~1996 kJ/match. Collectively, these findings support Ultimate Frisbee as an ideal alternative exercise modality.

There are numerous health benefits linked to regular physical activity; however, in a review of the international prevalence of physical activity found nearly 50% of the population did not meet the minimum requirements to be categorized as sufficiently active¹⁰. One factor that may be partially responsible for the lack of physical activity adherence in adults could be attributable to the ‘fun factor.’ It is possible that participation in more traditional exercise modalities (i.e. walking, running, cycling, swimming, etc.) may be associated with a decrease in the ‘fun factor.’ Alternatively, non-traditional modalities (i.e. Ultimate Frisbee) may be a way to get more adults involved in regular physical activity.

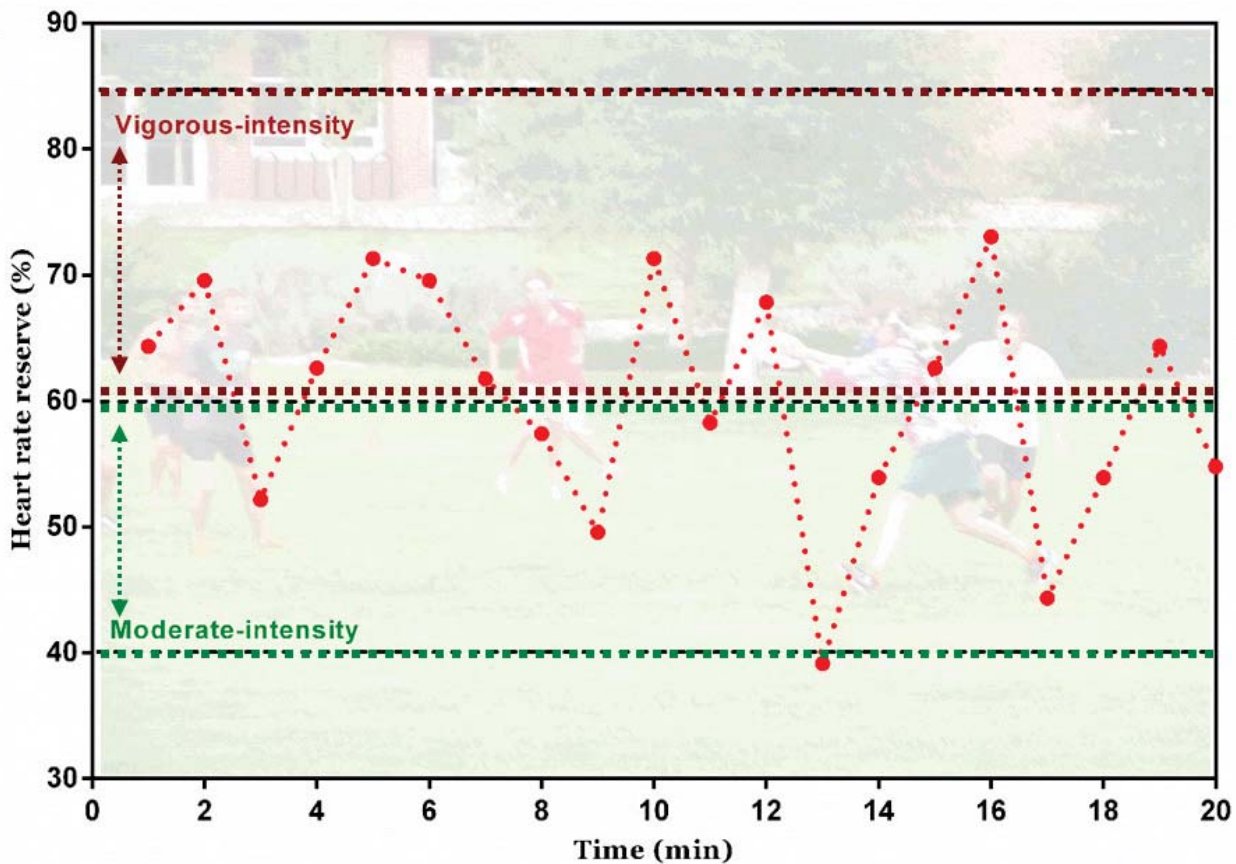


Figure 2 – Exercise intensity in terms of heart rate reserve (HRR) for a representative participant throughout the duration of one 20-min half of a simulated Ultimate Frisbee match. The lower region (denoted by dashed green lines) represents the moderate exercise intensity classification while the upper region (denoted by dashed red lines) represents the vigorous exercise intensity classification.

Ultimate Frisbee Exercise Intensity

Exercise intensity is arguably the most critical component of the exercise prescription model. Failure to meet minimal threshold values may result in lack of a training effect, while too high of an intensity could lead to over-training and negatively impact adherence to an exercise program¹¹. Results from the present study indicate Ultimate Frisbee can be classified as ‘*moderate-to-vigorous*’ according to various organisations definition of physical activity intensity^{2,4}. For example, ‘*moderate*’ exercise intensity in relative terms has been defined as 40-<59% of HRR/VO₂R⁴ while ‘*vigorous*’ exercise intensity has been defined as 60-<85% of HRR/VO₂R. Participants in the present study exercised at workloads during the simulated Ultimate Frisbee match that elicited HRR (65.3%) and VO₂R (61.2%) values that span the ‘*moderate-to-vigorous*’ exercise

intensity domains.

It is also important to highlight the considerable wide range in the HRR/VO₂R exercise intensity responses to Ultimate Frisbee (see ranges reported in Table 2). Although the mean exercise intensity response fell with the recommended ‘*moderate-to-vigorous*’ exercise intensity domains (i.e., 40-<85% HRR/VO₂R), it should also be noted that for some participants the HRR/VO₂R responses were near ‘*maximal*’ for small time periods throughout the Ultimate Frisbee match. Overall, research is quite clear that for most individuals the benefits of ‘*moderate-to-vigorous*’ intensity exercise substantially outweighs any risks; however, for a segment (i.e., *the moderate-to-high risk*) of the population, the risk of exercise-related events such as a heart attack or sudden death, is heightened when performing unaccustomed bouts of ‘*vigorous-to-maximal*’ exercise

intensity⁴. Consequently, caution may be warranted when recommending Ultimate Frisbee for more moderate-to-higher risk individuals (e.g., obese, Type 2 diabetic, or cardiac-diseased).

Metabolic Equivalent for Ultimate Frisbee

In the present study, the MET response to Ultimate Frisbee averaged 9.5 and ranged from 2.4 to 15.5. Thus, participants in the present study exercised at workloads throughout the Ultimate Frisbee match that elicited metabolic responses within the accepted vigorous-intensity range set by the 2008 US physical activity guidelines report¹² and elsewhere¹³. This is a noteworthy finding given the fact that vigorous-intensity exercise has been widely recommended for health benefits^{2,4,12}. Furthermore, MET values described in the present study compare favorably to more traditional land-based aerobic exercise values and non-traditional exercise values. For instance, treadmill and over ground running at 134 m/min is an equivalent vigorous-intensity physical activity at 8.6 METs. Likewise, it has been reported that snowshoeing at ~80.4 m/min equates to an absolute exercise intensity of 10-11 METs¹⁴. Similarly, Nicholson and colleagues (2007) demonstrated that rock climbing is a feasible '*vigorous-intensity*' alternative to more traditional aerobic exercise modalities for young adults that elicits a 7.2 mean MET value response.

Ultimate Frisbee Energy Expenditure

Much research has demonstrated that there is a dose-response relationship between exercise and numerous health outcomes, including cardiorespiratory fitness, risk of coronary artery disease (CAD) and all-cause mortality, obesity, dyslipidemia, type 2 diabetes, and colon cancer¹⁵. In fact, according to these dose-response relationships it has been noted that the health benefits of a program are associated with the total weekly energy expenditure⁴. Gross (total) energy expenditure includes both the resting metabolic rate and the energy expenditure attributable to the exercise itself (net caloric expenditure). For the improvement and maintenance of cardiorespiratory fitness, the ACSM has recommended a target energy expenditure of

627.6 to 1673.6 kJ/day (150 to 400 kilocalories per day). From a practical perspective, results from the present study highlight that participation in a 40-min Ultimate Frisbee match yields a mean energy expenditure of 1995.8 kJ (477 kcal) that satisfies the ACSM recommendations for daily energy expenditure. This volume of energy expenditure is comparable to other non-traditional outdoor activities. For instance, Schneider and colleagues (2001) reported that 30-min of snowshoeing in a sample of men and women elicited a total energy expenditure ranging from 1556.5 to 2188.2 kJ. Similarly, it has been demonstrated that 30-min of recreational kayaking in a cohort of young adults yields an overall caloric expenditure of ~2092 kJ¹⁷.

Blood Pressure Responses Post Ultimate Frisbee Participation

In the current study, there was a significant decrease ($p < 0.05$) in post-Ultimate Frisbee match SBP of -5.6 ± 5.1 mmHg, -8.6 ± 5.0 mmHg, and -8.7 ± 5.7 mmHg compared to pre-Ultimate Frisbee match at 30, 60, and 90 min, respectively. These data indicate a greater decrease of SBP compared to that previously reported in the literature with an acute bout of moderate-intensity exercise eliciting a decrease in SBP of 5-7 mmHg following the completion of the exercise session¹⁸. While it has been established that a single acute bout of moderate intensity exercise can lower SBP, there is also evidence that being outside for exercise can also help to decrease the SBP. Indeed, it has been found that simply being in nature compared to being in a city has the ability to decrease SBP, as well as, improve other physiological functions¹⁹. Similarly, an investigation of primary school children found a lowered SBP 15 min post-moderate intensity exercise when cycling with a simulated 'green environment' compared to not having this stimulation²⁰. Therefore, the reduced SBP in the current study may be attributable to a combination of the acute exercise bout and the outdoor exercise environment.

Methodological Considerations

Possible limitations to the present study merit discussion. The present study investigated the cardiovascular and metabolic responses to Ultimate Frisbee in a cohort of young, healthy, and fit individuals. The cardiovascular and metabolic responses to Ultimate Frisbee would most likely vary if assessed in samples with different demographics relative to those in the current investigation. Another possible limitation is the relatively short resting period used for collecting resting HR and VO_2 . However, unpublished pilot testing data from our laboratory found no significant differences ($p > .05$) between resting HR and VO_2 values obtained following 5- and 30-min of rest. Furthermore, resting values obtained in the present study are comparable to those reported elsewhere²¹. Lastly, a final limitation may be that cardiovascular and metabolic data were only directly quantified for one-half (i.e., 20 min) of the simulated Ultimate Frisbee matches for each participant.

CONCLUSIONS

The main findings of the current study indicate that Ultimate Frisbee meets the standard criteria for guidelines of physical activity and could be used as an alternative exercise modality and has the possibility to increase the ‘fun factor.’ Furthermore, there were significant decreases in SBP post-Ultimate Frisbee match indicating this exercise modality may be beneficial for acute reductions in SBP; however, measurements in non-fit, non-healthy participants is unknown.

Practical Application

- To our knowledge, this is the first study to investigate the cardiovascular and metabolic responses to Ultimate Frisbee.
- Findings from the present study support the activity of Ultimate Frisbee as a feasible alternative to traditional exercise modalities for adults that fulfills guidelines for improving and maintaining cardiorespiratory fitness and satisfies current energy expenditure

recommendations:

- Mean exercise intensity of Ultimate Frisbee corresponds to 65.3% of HRR, 61.2% of VO_2R , and 9.5 METs, respectively.
- Mean energy expenditure of Ultimate Frisbee equates to nearly ~2092 kJ per 40 min match.
- Overall, these findings are important for exercise physiologists, fitness professionals, and others who design exercise programs and promote physical activity in the adult population.

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