ACTION BALL: AN ANALYSIS OF ENERGY EXPENDITURE AND SUBJECTIVE EXPERIENCES OF PARTICIPANTS

A Dissertation

by

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ABSTRACT

Energy expenditure and subjective experiences of college students participating in action ball were examined through two studies. In Study 1, six students participated in action ball while using a portable metabolic analyzer. Energy expenditure data from these students were compared to American College of Sports Medicine (ASCM) daily activity recommendations. Participating in forty minutes of action ball exceeded the ACSM recommendation of 3.0-5.9 metabolic equivalent of tasks (METs). Participation in action ball did not, however, exceed the ACSM kilocalories (kcal) standard. In Study 2, hypotheses about differences between action ball and the other two sports were tested. Data from 109 students in five physical education classes were analyzed. Three of the classes (*n*=72 students) participated in action ball, one class participated in basketball (*n*=14), and one class participated in ultimate Frisbee (*n*=23 students). Heart rate (HR), kcal, and four indicators of subjective experience quality were measured during and immediately after participation. Action ball produced greater kcal expenditure than basketball. Action ball yielded significantly greater deep structured experience prevalence than basketball (Week 12). Action ball also yielded significantly less deep structured experience frequency than ultimate Frisbee (Week 12) and basketball (Week 12). Collectively, results suggest that action ball provides similar energy expenditure and experience quality to other similar sports.

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NOMENCLATURE

ACSM	American College of Sports Medicine
BPM	Beats Per Minute
CDC	Center of Disease and Control
CO_2	Carbon Dioxide
Db	Douglas Bag
DSE	Deep Structured Experience
DSEf	Deep Structured Experience Frequency
DSEp	Deep Structured Experience Prevalence
EEm	Energy Expenditure Measurement
GPS	Global Positioning System
$H_{1\ldots}H_8$	Hypotheses 1… Hypotheses 8
HR	Heart Rate
kcal	Kilocalorie (Unit of energy)
$K4b^2$	Portable Metabolic Analyzer Cosmed $K4b^2$ Machine
METs	Metabolic Equivalent of Tasks
PACES	Physical Activity Enjoyment Scale
PEAP	Physical Education Activity Program
PC	Recordable Computer
PU	Portable Unit
PVTS	Perceived Value of Time Spent
QOL	Quality of Life

SEm — Subjective Experience Measurement

SOTG — Spirit of the Game

SPSS — Statistical Package for Social Sciences

USDHHS — United States Department of Health and Human Services

VO_2 — Oxygen Consumption

VO_2 Max — Maximal Oxygen Consumption

$\%HR_{MAX}$ — Percent Heart Rate Max

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CHAPTER I

INTRODUCTION

Physical education teachers need opportunities to teach sports that are both high in energy expenditure and enjoyable for youth participants (Tessier, Sarrazin, & Ntoumanis, 2010). Such sports will not only yield high impact in terms of immediate fitness and health, but the pleasing nature of those sports may contribute to the development of habits of movement and physical activity. The period of transition between adolescence and adulthood is particularly pivotal because youth tend to develop habits for daily activity that may persist throughout their adult lives (Perkins, Caldwell, & Witt, 2018). Inactivity among adults is a major health concern. The Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) reported that 300,000 people die each year from health complications linked to physical inactivity (Haskell et al., 2007). American youth are not, on the whole, engaging in physical activity at sufficient levels of intensity, frequency, and duration (United States Department of Health and Human Services [USDHHS], 2018), nor are they developing habits of life-long participation in sport and physical activity.

Sports commonly taught through physical education include basketball, ultimate Frisbee[1], softball, and tennis. Energy expenditure for these sports during a bout of participation often meets ACSM recommendations. A single bout of participation in basketball or ultimate Frisbee during a 40-minute physical education class, for example, yields approximately 400 kcals

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[1] According to Adams (1987), an author must capitalize "Frisbee" when discussing the game ultimate Frisbee.

burned. The popularity of such sports suggests that students enjoy participation, and some youth do continue to be active when they become adults. It is possible, however, to design a sport that could be expected to burn more calories and be more enjoyable than these popular sports.

Action ball may be a sport (Nelson, 2017). Action ball is a non-contact, co-recreational, team sport that requires foundational components of popular sports like ultimate Frisbee, soccer, basketball, and football. Action ball participants run, kick, soccer-dribble, pass, block, and defend. The object of action ball is to score goals by throwing, kicking, or heading a soccer ball into a 10’x5’ soccer goal. Balls are advanced toward goals by running, soccer-style dribbling, and passing. Participants may run while holding the ball until they are tagged by an opponent. At that point, the game becomes much like ultimate Frisbee; the participant must stop and pass to a teammate. If the ball hits the ground, action ball becomes much like soccer; the ball may be advanced toward the goal only through contact with participants’ feet. Teams are comprised of six field players and one goal-keeper. Rapid transitions from offense to defense occur.

No studies have been conducted of energy expenditure during action ball. The nature of the competition, though, suggests that energy expenditure should be substantial. The activity is non-stop; participants are always in motion. The activity also involves periods of extremely intense exertion, as when an offensive player works to evade the tag of an opponent. Instances of dead-balls, penalties, and other interruptions of movement are minimal. Further, action ball has features that optimize enjoyment. Experiences that yield perceptions of success and efficacy (Bandura, 1989) give rise to enjoyment, as do opportunities to use self-relevant talents and skills (Ellis, Voelkl, & Morris, 1994). Action ball’s design includes both of these features. Anecdotal evidence gained through observation suggest that action ball has a relatively shallower learning curve compared to other team sports, and participants with diverse talents may succeed in different ways. A participant who is particularly adept at dribbling a soccer ball, for example, can experience success just as participants who have strong skills of throwing, catching, and evading defenders, like basketball and football. Other participants who have the skills of quickness, agility, balance, and coordination may experience success as goal-keepers. These assumptions, however, have not been subjected to empirical testing; therefore, the purpose of this study was to examine the energy expenditure and subjective experience of individuals playing action ball relative to those participating in two popular sports taught in physical education classes in the United States: basketball and ultimate Frisbee.

CHAPTER II

LITERATURE REVIEW

This chapter examines an integration of literature providing the foundation for this study. The first section reviews literature on physical activity and energy expenditure. Dimensions of energy expenditure that are explored include metabolic equivalent of task (MET), caloric output (kcal), and heart rate (HR) (ACSM, 2014). Next, literature on subjective experiences associated with physical activity and other structured experiences is reviewed. Subjective experiences addressed include enjoyment (Kendzierski & DeCarlo, 1991), deep structured experience, and perceived value of time spent (Ellis, Freeman, Jamal, & Jiang, 2019). The literature review then turns to the specific features of physical activity and exercise that may yield different quantities of energy expenditure and different subjective experiences. Included in that section are descriptions of three sports that play a prominent role in the study: action ball, basketball, and ultimate Frisbee. Next, a broader context for the study is established. The literature review summarizes benefits of physical activity and exercise, emphasizing youth (ages 15-25) as a pivotal period for developing lifetime habits of health-promoting movement. The chapter concludes with a summary and formal statement of research questions and hypotheses.

Energy Expenditure

Human beings consume food to produce the energy they need to carry out physical functions in their daily lives. Oxygen consumption is crucial to the metabolic process that converts food to energy, the amount of energy provided by food is scientifically measured by combustion and denoted in the units of calories. This unit of energy, calories, is a common term in the general public. It is important to note that food labels mark this unit of energy as Calories.

The capital C indicates 1,000 calories or 1 kilocalorie (kcal). These types of units of energy are important to understand for energy expenditure.

Energy expenditure has been of interest to exercise physiologists since 1955. Energy expenditure is dependent of physical activity, such as sport. Common measurements include percentage of maximum heart rate, kcal, and metabolic equivalent of tasks (METs). The estimation of energy expenditure can be measured by heart rate monitoring. This method is popular, convenient, relatively inexpensive, and versatile. The percentage of maximum heart rate is defined as the ability to quantify the intensity of exercise (Hills, A.P et al., 2014).This is highly dependable when exercise is at steady state, but can still be used in non-steady state exercise like basketball and ultimate Frisbee. Kcal can be used to measure the activity energy expenditure which represents all energy expended above resting level and energy costs associated with the ingestion and assimilation of food. This method is a direct measure of the energy cost of the physical activity and may be used to measure the energy cost of an activity (Hills, A.P et al., 2014). METs equates with the oxygen consumption required at rest or sitting quietly and is assumed to be 3.5 mL/O_2/min x kg body weight (Jette, Sidney, & Blumchen, 1990). When an individual is participating in sport and that requires more oxygen intake than sitting, then the METs score will be higher for the activity than when the person is sitting.

In laboratory settings, measurement of respiration (oxygen consumption) is the gold standard for estimating energy expenditure (Achten & Jeukendrup, 2003; ACSM, 2014; Laukkanen & Virtanen, 1998; Nichols et al., 2009). Direct and indirect approaches to measuring oxygen consumption exist. Direct calorimetry is not practical in a sport setting due to the changes in body mass, sweat and heat production. With physical activity, indirect calorimetry is the measure of oxygen consumption and has been determined to be a valid and reliable measure of metabolic rate (Beato, Impellizzeri Coratella, & Schena, 2016; Dallack, Bryd, Velde & Weatherwax, 2016; Laukkanen & Virtanen 1998). Indirect calorimetry is used in exercise physiology because it is easier and more reliable than direct calorimetry (Brooks et al., 2000). Some sports, like action ball, basketball, and ultimate Frisbee, present challenges collecting data in a laboratory setting because of the playing fields, equipment, and unpredicted movement.

A variety of electronic devices have been used to estimate energy expenditure indirectly through measurement of oxygen consumption during physical activity. Historically, the most common device used to measure oxygen consumption was the Douglas bag (Db) technique. The Db technique was developed in 1911 as a way to collect exhaled gases outside the laboratory (Shephard, 1955). One of the major disadvantages of the Db collection method is that it only provides averages of the gases collected. Even though this technique is still considered to provide reasonable estimates, new advances in oxygen collection have occurred, such as the portable metabolic analyzer Cosmed $K4b^2$ machine ($K4b^2$) (Duffield et al., 2004a; Schrack et al., 2010). The newer systems complete breath-by-breath analysis. In addition to the breath-by-breath, the newer systems are able to instantaneously gather information from the same exercise session. Db procedures do not permit such data collection. Portable breath-by-breath systems increase ease as well as function for energy expenditure experiments (Schrack et al., 2010).

Cosmed $K4b^2$ yields data comparable in precision to that of other devices designed for similar purposes. In addition to Db, other completely portable gas analysis systems have been created. Metabolic carts, for example, are portable machines that also read expired gases. Several studies have compared the breath-by-breath analyzers such as the $K4b^2$ to the Db method and metabolic carts. Duffield, Dawson, Pinnington, and Wong (2004b) found that when compared to conventional metabolic cart, the $K4b^2$ overestimated VO_2 values. Schrack et al. (2010) found that all values were steady during the metabolic collection. Other researchers have supported Schrack's findings (Duffield et al., 2004b; Maiolo, Melchiorri, Iacopino, Masala, & De Lorenzo, 2003). Small sample sizes and different methods could be a part of the reason differences occurred.

The K4b^2 device has features that can be particularly helpful to researchers studying energy expenditure during physical activity. In addition to oxygen consumption, that device also reports measures of other variables that indicate energy expenditure within an exercise session such as kilocalories (kcal), METs and heart rate (HR). All of these units of energy have been validated to measure energy during an activity session (Achten & Jeukendrup, 2003, ACSM, 2014; Dallack, Bryd, Velde & Weatherwax, 2016; Haskell et al., 2007; Karvonen & Vuorimaa, 1988; Montgomery, Pyne, & Minahan 2010).

Heart Rate Monitors

HR is a useful indicator of physiological adaptation and the intensity of the exercise (Puyau, Adolph, Vohra, & Butte, 2002). HR is an individual's response to physical activity. HR measurement provides an indication of the relative stress placed on the cardiorespiratory system during movement (Karvonen & Vuorimma, 1988). Physical activity is dependent on the amount of oxygen the body is taking in; therefore, HR monitoring can also be used to estimate the metabolic cost (energy expenditure of physical activity). Energy expenditure and physical activity are interrelated because energy expenditure is an outcome of physical activity. To ensure accurate readings, it is essential to use HR monitoring because manual pulse palpation provides inaccurate results (Laukkanen & Virtanen, 1998).

Numerous instruments detect HR. In the past decade, companies have created user friendly wearable devices for consumers to track their activity (Brumback, Myers, Yuen, Park, &

Diemer, 2015; Evenson, Goto, & Furberg, 2015). These devices are typically wrist watches, phones, or wrist devices to track steps, HR, and overall activity for a certain duration. Consumer wearable devices are a popular and a growing market for individuals to monitor activity (Brumback et al., 2015; Wallen, Gomersall, Keating, Wisløff, & Coombes, 2016).Wearable devices are new options for tracking energy expenditure, sleep patterns, and overall health-related metrics. El-Amrawy and Nounou (2015) posit wearable devices that track fitness are relatively accurate, but there have not been enough studies to prove the overall accuracy and precision. Some studies report that consumers should be careful using commercial fitness trackers to estimate energy expenditure during field-based activity (El-Amrawy & Nounou, 2015; Hongu, Orr, Roe, Reed, & Going, 2013; Wallen et al., 2016).

Many studies have examined the accuracy of wireless HR monitors (Janz, 2002; Leger & Thivierge, 1988; Puyau et al., 2002; Welk, 2002). These studies have covered numerous modes (e.g., cycling, basketball, stair stepping) and intensities (e.g., resting, moderate, vigorous). Leger and Thivierge (1988) compared the numerous brands of HR monitors, and Polar company that produces HR monitors, received excellent marks in terms of stability and functionality. Since the birth of Polar HR monitors, its products have been recognized as the most accurate tools for HR monitoring and registering in the field (Crouter, Albright, & Bassett Jr, 2004; Hongu et al., 2013; Laukkanen & Virtanen, 1998; Reed, De Souza, & Williams, 2013; Welk, 2002). Research has, therefore, consistently supported the validity of measures provided by devices like Polar.

To ensure stronger reliability, most transmitters that detect HR use the electrocardiogram (ECG) signal that is attached to the chest (Janz, 2002; Laukkanen & Virtanen, 1998). A seminal study conducted by Karvonen and Vuorimaa (1988) validated the use of ECG recording instruments and the use of percent heart rate max (%HR_{max}) in cross country skiing and alpine skiing. The researchers were able to measure the workload in both sports and determine the specific HR zones of participants. Research reports HR zones indicate various intensity zones (Achten & Jeukendrup, 2003). Environmental and physiological factors have an influence to exercise parameters such as activities, weather, and cardiovascular fitness. Collection of HR has been used to evaluate exercise responses for a very long time. One specific device Polar designed is the FT4 Polar Heart Rate Monitor. This device is equipped with H1(H1 is the device name) heart rate sensors and are a highly rated product from Polar (Hongu et al., 2013). Those devices come with chest straps and wristwatches. This chest strap device transmits the data from the chest strap to the wrist watch in coded form. Coding prevents any kind of interferences from other devices; thus providing accurate indirect calorimetry readings that belong to a specific participant. The technology has rapidly changed and made instrumentation more reliable and stable during different conditions (Hongu et al., 2013).

Subjective Experience Associated with Physical Activity

In 2012, *Lancet*, published a series of articles on the global trends and impacts of physical inactivity. This approach was a broad look at the topic and concluded that physical activity is not solely dependent on sport and exercise. Rather, it is more about the relationship between human beings and the environment in which they are being physically active (Bauman et al., 2012; Das & Horton, 2012). Enjoyment has been directly linked to increasing participation in an activity (Deci & Ryan, 1987; Dishman et al., 2005). Research suggests that a person’s subjective experiences (interest, attention, motivation, emotion) has repeatedly been found to be a powerful influence on learning (Hidi & Renninger, 2006; Ntoumanis, 2001; Subramaniam, 2009; Tessier et al., 2010).

Even though subjective experience has been recognized as an important role in learning, teachers still struggle with helping disengaged students become excited about learning (Hidi & Renninger, 2006). Ideally, teachers are aware of disengaged students, and they take actions to elevate those students' learning experiences. It is difficult, though, for physical education teachers to cater to each student's individual preferences and abilities (Tessier et al., 2010). Teacher awareness of specific strategies can help address this challenge. Enjoyment and interest have a non-recursive, bidirectional causal effect; each influences the other (Subramaniam, 2009). Teachers who understand techniques for elevating both enjoyment and interest are well positioned to engage the majority of students in their classes (Tessier et al., 2010).

Research on strategies for increasing enjoyment requires quality measurement. Studies have found significant predictors of an increase of participation when respondents reported high enjoyment of an activity (Kendzierski & DeCarlo, 1991; Leslie et al., 1999; Moore et al., 2009; Nahas, 2001; Sallis et al., 1992; Salmon et al., 2005). A popular approach to measuring enjoyment of physical activity is the Physical Activity Enjoyment Scale (PACES). PACES is a multi-item measure, which has been validated in a number of studies (Crocker, Bouffard, & Gessaroli, 1995; Kendzierski & DeCarlo, 1991; Motl et al., 2001). PACES is useful because it also evaluates negative affective responses, such as dislike of exercise, that have previously been shown to predict physical activity (Williams, Anderson, & Winett, 2005). The PACES approach defines enjoyment as a positive affective state that reflects feelings such as pleasure, liking, and fun. Sample items on that instrument include "I find it energizing," "It is a lot of fun," and "I like it." The response format is a 7-point Likert-type (I enjoy it—I hate it). A single, overall score is obtained by summing across responses to individual items.

Three studies have examined the validity of inferences PACES users can make from test scores. Crocker, Bouffard, and Gessaroli (1995) gathered data from 279 youth camp participants (159 males and 120 females) with a mean average of 14.4 years. The participants competed in basketball, soccer and other sports. Participants were instructed “to rate how you feel at the moment about the physical activity that you have been doing” once they completed the activity. A classical test theory approach was taken to psychometric evaluation of the PACES. Item-total correlations ranged from r_{IT}=.38 to r_{IT}=.76. The internal consistency, as assessed by Cronbach’s (1951) coefficient alpha was α=.90. These findings were consistent to those reported by Kendzierski and Decarlo (1991).

Motl et al., (2001) measured enjoyment of 104 adolescent girls participating in physical activities. These girls participated in thirty-minute blocks of physical activity (i.e. cycling, running, and other physical education type activities) that reached moderate to vigorous intensity. Researchers tested a congeneric measurement model using structural equation techniques. Their model fit PACES well. The relative non-centrality index was .95 and non-normed fit index equaled .95.

Kendzierski and DeCarlo (1991) also conducted a study addressing the validity of inferences users can make from a situation-specific version of PACES. The original PACES measures enjoyment of physical activity in general. Twenty-one males and twenty-three females between the ages of 18 to 24 participated in twenty-minute bouts of exercise of cycling or jogging. The internal consistency coefficient was α=.90 and item-total correlations ranged from r_{IT}=.38 to r_{IT} .76 (Crocker et al., 1995).

Perceived Value

Value is a concept that has been studied widely in consumer behavior (Oliver, 2014) tourism (Petrick, 2002, 2004), and hospitality (Gallarza, Arteaga, Del Chiappa, & Gil-Saura, 2015; Ryu, Lee, & Gon Kim, 2012). A valued activity could be an indication that the participant would repeat the activity again. Perceived value of time spent has been argued to be the most important indicator of repeating an activity or revisiting a destination (Cronin, Brady, & Hult, 2000; Oh, 2000; Parasuraman & Grewal, 2000). This concept can be applied to college-age students and physical activity. In a study conducted by Ellis et al., (2017), the researchers defined perceived value as “the individuals’ degree of contentment with her or his decision to participate in the structured experience.”

In a more recent study, Ellis et al., (2018) had two teams of education tourist visit 23 attractions and tourism industry businesses on three Hawaiian Islands. One team evaluated the service quality of each attraction while the other team reported the quality of their experiences at that attraction. A total of 274 usable experience observations were obtained along with evaluations of service performance and experience structuring performance for each of the 23 attractions. Perceived value of time investment (b=.44, t=7.09, p< .001) was a significant predicator of proclivity to promote the attraction. Additionally, a study monitoring structured experiences during youth programs supported validity of inferences that can be made from scores on the perceived time spent scale (Ellis, Taggart, Martz, Lepley, & Jamal, 2016). Two hundred and nineteen youths from various clubs participated in the study. Their average age was 12.40 years. The Cronbach alpha estimate of reliability of the four-item measure of perceived value was .82. All correlation coefficients supported criterion-related evidence of validity. All coefficients were significant ($p<.001$). The correlation between perceived value and engagement was $r=.52$ ($p<.001$).

Theoretical Framework of Structured Experience

In addition to measuring the physiological benefits of physical activity, it is also important to measure the subjective experiences that an individual has during that activity (Ellis et al., 2017; Henderson et al., 1999). Theory about subjective experiences and their link to physiological benefits is essential to achieve scientific understanding. Leedy and Ormrod (2005) define theory as, "an organized body of concepts and principles intended to explain a particular phenomenon." Examples of theories include self-efficacy, self-determination, prosocial behavior, and structured experience. Zetterberg (1963) suggests that strong theories are productive and are parsimonious. The theories include constructs, definitions, assumptions, propositions, and hypotheses. Propositions are based on reasoning from existing knowledge and observation. The purpose of the proposition is to advance the notion that the two variables are related. Zetterberg (1965, p. 21) says, "both researchers and practitioners learn to extract the ordinary propositions from the theoretical ones. Propositions of low informative value are legion, and I shall simply call them ordinary propositions. Propositions of high informative value deserve to be called theoretical propositions." Jaccard and Jacoby (2010) add that all theories consist of variates/variables and relationships between those variates.

One theory in particular has bearing on this study—the theory of structured experience, which defines four subjective states of consciousness: engagement, immersion, absorption, and deep structured experience (Ellis et al., 2017). Examples of activities for which the engagement experience is relevant are listening to a conference presentation, chatting with a colleague, or watching a movie. Immersion is an instance of "microflow" experience and is often affected by challenges or different skill-related activities and the self-relevance of those activities (Ellis, Voelkl & Morris, 1994). Examples of activities that give rise to immersion experiences include playing a board game, learning to swim, acting in a play, or painting (Csikszentmihalyi, 1975). Absorption experiences are a result of activities that create sensory experiences. These types of experiences can be associated with listening to calming music, enjoying a beautiful piece of art, and tasting a delicious hors d'oeuvre. Heightened states of experience occur during the point of service. Deep structured experience (DSE) can be facilitated through techniques such as a theme, personalizing the experience, or having a clear narrative for the participant (Ellis, Freeman, Jamal, & Jiang, 2017). DSE links closely to physical activity and measuring the experience of a participant.

Defining Deep Structured Experience

Whether in the realm of recreational sports or competitive sports, experience is the quintessential product of these programs (Kim, Ritchie, & McCormick, 2010; Morgan, Lugosi, & Ritchie, 2010; Mossberg, 2007; Rossman & Schlatter, 2011). For organizations in these experience programs (Nilsen & Dale, 2013; Pine & Gilmore, 2011), understanding the essential characteristics of experience is the foundation for designing services and encounters that meet needs and enhance success of recreation, sport, and tourism businesses in highly competitive environments (Pine & Gilmore, 2011). In physical activity, it can be assumed if participants are in a state of effortless concentration during the activity, they could be motivated to participate in this activity again. Deep structured experience (DSE) results from high levels of engagement, immersion, or absorption. Ellis et al. (2017, p.7) formally define deep structured experience as "a state of effortless concentration during which individuals lose (a) their sense of time, (b) their thoughts about themselves, and (c) awareness of their problems."

Although deep structured experience is an unobservable construct, the approach to measure the phenomenon follows from observations by Suen's, Ary's, and Covalt's (1990) observation. This observation is that observable behavior during a given time interval has three dimensions: prevalence, frequency, and pattern. Measurement of deep structured experience includes characterizing the occurrence versus absence of deep structured experience over the course of the structured activity (Suen et al., 1990). A structured experience is one that involves behavioral action and reaction (e.g., participating in a sport, knitting, dancing). These constructs are synonymous with seminal studies of experiences of surgeons, rock climbers, chess players, dancers, and musicians (Csikszentmihalyi, 1975).

Theory of structured experiences also defines a structured experience as, "a planned invitation extended by an experience provider for a heightened subjective state of motivation, attention, and emotion to occur" (Ellis et al., 2017, p.9). In other words, an experience that is provided has a beginning and end that is dependent on the participant and provider. Dyson (2002), a prominent scholar in the field of physical education, presents the idea that experiences can be enhanced through the modification of certain aspects of the learning environment and contextual factors such as teaching strategies, task presentation, and structured learning experiences. Theory of structured experience has the potential to be an important step in understanding how people experience physical activity. While a number of propositions regarding the theory of structured experience propositions have been tested for validity (e.g. Ellis, Lacanienta, Freeman, & Hill, 2018; Lacanienta, Ellis, Taggart, Wilder, & Carroll, 2018), select propositions of deep structured experiences have not yet been empirically examined. The Ellis et al., (2018) study had two teams of education tourists visit 23 attractions and tourism industry businesses on three Hawaiian Islands. A total of 274 usable experience observations were obtained along with evaluations of service performance and experience structuring performance for each of the 23 attractions. Prevalence of deep experience was a significant predicator of perceived value of time investment ($b=.39$, $t=6.17$, $p<.001$). Deep structured experience, therefore, will be the main focus of this dissertation.

Activity Features Related to Energy Expenditure and Subjective Experience

In this section, features of action ball, basketball, and ultimate Frisbee are examined in terms of their relation to energy expenditure and potential for elevating enjoyment, deep structured experience, and perceived value of time spent. The history and popularity of each of these activities is briefly presented, along with specific features that may impact energy expenditure and subjective experience.

Action Ball

The sport known as action ball originally came from Orlando, Florida, where a strength coach incorporated a similar game for his athletes. This game was a full contact game designed for strength and agility. The game then traveled to Tulane University where it was referred to as "Wave ball" and became popular. In the mid 1990s the sport made its way to Louisiana State University and "Tigerball" became the new name for this sport. An LSU football quarterback modified the game and introduced the Fellowship of Christian Athletes to Tigerball. The game had been adjusted to have less contact and more running.

In 2015, Chad Nelson (the author of this dissertation) took components of Tigerball and created action ball. An action ball team consists of one player playing goalkeeper and six field players. Players compete using a soccer ball and are allowed to handle and throw the ball until their opponent touches them. The offensive person then has 10 stall counts to release the ball. If the ball falls to the ground, the game then becomes soccer. The only way to bring the ball back to the hands is by contacting the ball with the foot. Each team also has a goalkeeper set to block incoming balls from entering the goal. A goal is scored when an in-bounds player throws (1pt.), kicks (2pts.), or heads the ball (3pts.) into the goal. The objective is to score as many points possible while keeping the other team from scoring. The game is self-officiated, and the team with the most points in a match wins the game. Games generally consist of two 20-minute halves.

Nelson (2017) suggests action ball has the potential to become a significant response to the inactivity problem among college students. Action ball is "an awe-inspiring team sport…Any athlete can participate in this controlled, non-contact team sport" (Nelson, 2017, p. 2). Action ball's features highlight enjoyment levels for participants, while also motivating them to increase their physical activity. Action ball is a non-contact, co-ed friendly, team sport that has foundational components of popular sports like ultimate Frisbee, soccer, basketball, and football. The new sport was designed to have a relatively shallower learning curve compared to other team sports and could produce similar exercise measures to achieve weekly ACSM guidelines for physical activity, proving to be an encompassing activity for all ages and skill ranges (ACSM, 2014; Haskell et al., 2007), although to date no studies have been conducted to support these assertions.

Implementation of preliminary programs suggest that action ball can be rapidly taught to young individuals of varying skill backgrounds and abilities, using minimal equipment and with great flexibility of team sizes, to quickly incorporate as many individuals as possible into a moderate-intensity activity. The author of this dissertation by no means is stating physical education teachers should drop all other sports, but rather provide another tool for the curriculum. This activity may or may not be a success among the students. The addition of this sport into university physical activity programs may provide a viable option for exercise among college students. Assumptions about enjoyment and physiological responses have not, however, been tested.

Basketball

In the late 1800s, baseball and football gained popularity. Football, however, while popular sport elicited fatal injuries (Gorn & Goldstein, 2004). Players were often playing without protective gear and collisions between participants were dangerous for participants. Baseball was considered the most popular sport, but required natural light, outdoor settings, and a lot of equipment. There seemed to be a need for an indoor sport that would require artificial light, ease of learning and enjoyment of play in the harsh winter months.

In 1891, James Naismith, a graduate assistant responsible for teaching physical education courses at Springfield College created basketball. Naismith took components from American and English Rugby, soccer, and lacrosse to create basketball. He created 13 rules that described how the ball was to be moved from player to player and what constituted a foul. While he wanted to create a sport that was indoors, he also wanted a sport with less contact. In 1905, colleges and high schools began implementing the sport as an official winter sport. Basketball was created to meet specific needs set out by Naismith, but the game had a large impact on urban recreation in the twentieth century. Basketball provided an opportunity for an expansion of organized play for not just men, but women and children (Gorn & Goldstein, 2004). Basketball was an accessible sport to be played in more urban areas. Recreational facilities were able to accommodate citizens by building local courts in communities.

In the 21st century, basketball is one of the more popular sports among university students. This team sport also elicits moderate-to-vigorous intensity (Ainsworth et al., 2011).

Basketball has two teams of five players. Each team tries to score by shooting a ball through a hoop elevated 10 feet above the ground. The game is played on a rectangular floor called the court, and there is a hoop at each end. The court is divided into two main sections by the mid-court line. Each team is assigned a basket or goal to defend. Recreational games typically last anywhere from 30-40 minutes with small breaks during the game.

Ultimate Frisbee

Ultimate Frisbee is a team sport that elicits measurable physiological responses in terms of HR and energy expenditure (Dallack, Bryd, Velde & Weatherwax, 2016). The object of the game is to pass the Frisbee to a team member (seven vs. seven) in a team's respected end zone. Games begin with each team lining up in front of their respective end zone line. The defense initiates play by throwing the disc to the offense. The offensive team must throw the disc to each other. Players who catch the Frisbee must immediately establish a pivot; a point of contact on the ground. When a pass is not completed (i.e. Frisbee hits the ground, is intercepted, or goes out of bounds) the defensive team then becomes the offensive team. Players may not run with the disc. The games are self-officiated and whichever team has the most points at the end of a match is the winner (Dallack et al., 2016).

Developed in the late 1960s, ultimate Frisbee is a fast-paced sport of non-stop movement and athletic endurance along the lines of soccer coupled with skills from popular sports like basketball and football. The sport was conceived in the midst of political assassinations, the Vietnam War, urban riots and civil rights unrest (Griggs, 2009). The culture of the game manifested from participants playing with an understanding of fairness and fun. The players found a sense of escape when playing this game. Griggs (2009) says, "the values and behaviors were based upon humanistic psychology where in a supportive environment people could work towards self-actualization." In other words, participants of ultimate Frisbee used this sport as a vehicle to navigate through challenging times.

Few studies conducted during that time measured enjoyment of and physiological benefits to participants. Numerous players have spoken on their experience while playing ultimate Frisbee. In the documentary *Flatball – A History of Ultimate*, players from the past four decades would mention their joyous experience when playing (Warsen, 2016). Chris Erskine, a *Los Angeles Times* columnist wrote, "what really struck me was just the joyfulness of the whole thing. Sports should be fun and that's why it all started." In 1989, just twenty years after its birth, the sport had reached 20,000 people playing around the world. Now, it is estimated to have over 5 million men, women, and children playing on six continents (Warsen, 2016). There are no officials or referees to monitor the game, but rather players are governed by the "Spirit of the Game" (SOTG). SOTG refers to a philosophy that players will abide by values of good sportsmanship and fairness throughout a match. This philosophy is designed for players to focus on the fair-mindedness and fun that competition can create.

It was not until 2016 (Dallack, Bryd, Velde & Weatherwax) that the *ACE Prosource Journal* fitness program decided to test if ultimate Frisbee participation yielded cardiovascular and metabolic responses that would meet existing guidelines for improving and maintaining cardiorespiratory fitness. Sixteen college-aged (19-21), non-trained, recreational players were recruited for this study. The results from this study found that a participant exerted 477 kcal/match and 11.9 kcal/min. It is clear that ultimate Frisbee is an ideal exercise modality to meet a target of 400 kilocalories burned through exercise each day (ACSM, 2014). Participants also yielded 9.5 METs during game play. Each participant had his or her cardiovascular and metabolic responses assessed during a twenty-minute half of the match, and the results were then extrapolated to account for a full match of forty minutes. The findings concluded that ultimate Frisbee is a team sport in line with moderate-to-vigorous intensity exercise.

Physical Activity and Exercise: Significance and Research

This section of the literature review addresses three related topics. First, literature showing the health benefits of physical activity is reviewed. Next, the literature review examines the extent to which inactivity among United States citizens is resulting in these benefits not being realized. The section concludes with a summary and integration of research directed at helping youth develop habits of physical activity.

Health Benefits of Physical Activity

Childhood and adolescence are critical periods for developing movement skills, learning healthy habits, and establishing a firm foundation for lifelong health and well-being. Regular physical activity in children and adolescents promotes health and fitness. Compared to those who are inactive, physically active youth have higher levels of cardiorespiratory fitness and stronger muscles (Krebs et al., 2007). Youth who are regularly active also have a better chance of a healthy adulthood. Regular physical activity also makes it less likely that these risk factors will develop and more likely that children remain healthy when they become adults (Perkins et al., 2018).

Children and adolescents do not usually develop chronic diseases, such as heart disease, hypertension, type 2 diabetes, or osteoporosis. Evidence shows that obesity and other risk factors for these diseases, such as elevated insulin, blood lipids, and blood pressure, are increasingly appearing in children and adolescents. Schwimmer et al., (2003) examined the health-related quality of life (QOL) of obese children and adolescents compared with children and adolescents who are healthy. Schwimmer et al., (2003) assessed the QOL for 106 children and adolescents

(57 males) between the ages of 5-18 years (mean *[SD]*, 12.2 [3] years). Compared with healthy children and adolescents, obese children and adolescents reported significantly ($p < .001$) lower health related QOL in all domains. Domains included physical, emotional, social, health and school functionality.

The CDC and ACSM issued a public health recommendation that adults (18-64) need at least 150 minutes of moderate-intensity exercise per week. This is equivalent to engaging in activities with intensity levels from 3.0 to 5.0 METs and a target of 400 kilocalories burned each day through exercise (ACSM, 2014; Johnson, Hayes, Brown, Hoo, & Ethier, 2014). The purpose of the recommendation was to provide a clear, concise, public health message that would encourage increased participation in physical activity. Vigorous-intensity (requires 6.0 METs or more) activity is exemplified by activities that cause a greater increase in breathing and a substantial increase in heart rate. These types of intensities can be measured by minutes in an activity. The total amount of physical activity (minutes of moderate-intensity physical activity in a week for example) is more important for achieving health benefits than any one component of frequency, intensity, or duration (Bailey, Hillman, Arent, & Petitpas, 2013). All time spent in moderate or vigorous-intensity physical activity counts toward meeting the key guidelines recommended by the USDHHS (2018), and the ASCM (2014). Meeting the weekly physical activity requirements is an important component for regulating body weight and combating obesity, and physical activity may also reduce the risk of chronic diseases (Ogden et al., 2014). The benefits of physical activity and exercise are clear. Physical activity and exercise create stronger intellectual, physical, social, and emotional health (USDHHS, 2018; Ogden et al., 2014).

Inactivity: A Significant National Problem

The Physical Activity Report Council (2017) reported 82.4 million U.S. Americans were inactive in the year 2017. These numbers indicate the existence of a significant national problem. Physical inactivity among youth has tremendous health risks and serious implications to their well-being (American College Health Association, 2012; Ogden, Carroll, Kit, & Flegal, 2014; Schwimmer, Burwinkle, & Varni, 2003). According the USDHHS (2018), lack of physical activity is linked to approximately $117 billion in annual health care costs and about 10% of premature mortality. The reduction in susceptibility to such diseases would drastically reduce the current health care cost burden (Bailey et al., 2013).

Research from national surveys and longitudinal cohorts has identified the transition between adolescence and adulthood as a period of increased risk for excess weight gain. According to the National Health and Nutrition Examination Survey data indicates the prevalence of obesity among young adults has continued to increase since 1999 (Flegal, Carroll, Ogden, & Curtin, 2010). Vandeboncoeur et al. (2015) reported weight gain during their freshman year is considerably greater than the general population. Levitsky, Halbmaier, and Mrdjenovic (2004) quantified the weight gain of freshman during their first 12 weeks at Cornell University. A total of 60 students were weighed and measured for this study. The study concluded the freshman gained on average (158g/week) in comparison to the general public of 8g/week. This is a significant health concern because of the association between excess body weight and numerous chronic diseases such as diabetes, cardiovascular disease, and some forms of cancer (American College Health Association, 2012; Health & Services, 2009; Lee et al., 2012).

USDHHS (2018) asserts, adults who are physically active are healthier, feel better, and are less likely to develop many chronic diseases, such as cardiovascular disease, type 2 diabetes, and several types of cancer than are adults who are inactive. The American College Health Association (2012) concludes, "increased amounts of moderate to vigorous physical activity are associated with improved cardiorespiratory and muscular fitness, including a healthier body weight and body composition" (p. 56). This time in college coincides with the beginning of the trajectory of the nearly twofold increase in overweight and obesity in the general U.S. population from 34.3% at ages 12-19 years to 57.1% at ages 20-30 (Ogden et al., 2014). The transition into college and adulthood is pivotal to establishing lifetime habits of physical activity (USDHHS, 2018; Ogden et al., 2014).

Research on development of habits of physical activity

American youth vary in their physical activity participation. Some do not participate at all, others engage in recommended activity, and some exceed guidelines set by the ACSM. Recommendations for appropriate amounts and types of physical activity for the U.S. population, including children and adolescents (aged 3-25), have been developed by several researchers and government agencies (Strong, Mathers, Leeder, & Beaglehole, 2005). Although many reviews indicate the benefits of physical activity, this section focuses on potential strategies to create healthy habits before fully transitioning into adulthood.

A review of evidence-based, physical activity for school-age youth was conducted to examine the effects of physical activity on health and behavior outcomes and develop evidence-based recommendations for physical activity in youth (Strong, Mathers, Leeder, & Beaglehole, 2005). Under a contract with the Divisions of Nutrition and Physical Activity and Adolescent and School Health of the Centers for Disease Control and Prevention and the Constella Group, an expert panel was assembled to review and evaluate available evidence on the influence of physical activity on several health and behavioral outcomes in youth aged 6 to 18 years. The study design was a systematic review that identified 850 articles. In the recommendations section for physical activity, the research concluded both physical education and recess afford opportunities to achieve the daily criterion. The recommended 60 minutes or more of physical activity can be achieved in a cumulative manner in school during physical education, recess, intramural sports, home, and community programs (Strong et al., 2005).

Sterdt, Liersch, and Walter (2014) conducted a systematic review that identified promoting correlates associated with the physical activity of children and adolescents (aged 3-18). Nine systematic reviews without meta-analysis and one systematic review with meta-analysis were selected. The research used was published between 2000 and 2009. The results supported that participation in community/organized sports, support from environment, access to facilities/programs, and time outdoors assisted with physical activity. The correlates are consistent with presently available scientific evidence and in general accord with recommendations promoted by governmental agencies.

Increasing the level of habitual moderate-to-vigorous intensity physical activity in youth is a health promotion and a disease prevention strategy. A practical strategy to promote physical activity is to replace sedentary behavior with activity whenever possible. Engaging in age appropriate and safe physical activities, such as sports and games, can reduce sedentary habits and replace them with healthy habits (Ebbeling, Pawlak, & Ludwig, 2002; Koh, 2010). This promotion of physical activity requires a multifaceted effort. The message that physical activity is beneficial must be repeated from home, recreation facilities, schools, and the media. Bauman et al. (2012) supports the promotion of physical education curricula in the schools and the availability of a range of physical activity programs and opportunities that accommodate adolescents in their communities.

Despite the limitations of databases in regards to recent advancements in technology and the impacts on physical education, there is substantial evidence that regular physical activity produces multiple beneficial physiological and psychological outcomes during adolescence. The strength of these findings leads to recommendations for all young people to develop healthy physically active habits on a regular basis (ACSM, 2014).

Conclusion

Physical inactivity among college students is a growing problem. This problem of inactivity may lead to obesity and a variety of health-related diseases (Buckworth & Nigg, 2004; Jung, Bray, & Ginis, 2008; Koh, 2010; Milroy et al., 2012; National Survey of Children's Health, 2016). This study seeks to proactively change attitudes of sedentary individuals by introducing an alternative physical activity. This research could contribute to the body of knowledge related to the experience, measurement of fitness, and enjoyment of physical activity. Conducting a study to measure an individual's experiences with a physical activity has the potential to understand perceptions and motivations to participate in physical activity. In addition to conceptual research, future empirical research with valid and reliable measures is needed, and will allow researchers and practitioners to better understand peoples' experiences with physical activity. With a growing need for college students to be physically active, action ball could provide a healthy alternative to individuals who want to be active.

From a social science and physiological perspective, there is no empirical evidence that supports students will elicit greater enjoyment while participating in action ball. There is no evidence that supports participating in a game of action ball will meet ACSM requirements for energy expenditure. In addition, a sizeable body of literature in physical education and leisure studies supports the idea for engaging experiences and enjoyment during activities. The specific hypotheses tested will be as follows:

H_1: METs of action ball participants will exceed the American College of Sports Medicine daily recommendations for moderate-intensity physical activity.

H_2: A single session of action ball will produce a number of kcals burned that exceeds the ACSM full-day recommendation for number of kcals burned.

H_3: The percentage of max heart rate of action ball participants will be higher than ultimate Frisbee participants and basketball participants at both weeks 5 and week 12.

H_4: The kcal expenditure of action ball participants will be higher than ultimate Frisbee participants and basketball participants at both weeks 5 and week 12.

H_5: Enjoyment of action ball participants will be higher than ultimate Frisbee participants and basketball participants.

H_6: Perceived value of time spent of action ball participants will be higher than ultimate Frisbee participants and basketball participants.

H_7: Prevalence of deep structured experience of action ball participants will be higher than ultimate Frisbee participants and basketball participants.

H_8: Frequency of deep structured experience of action ball participants will be higher than ultimate Frisbee participants and basketball participants.

CHAPTER III

METHOD

Two studies were conducted. The first study involved use of an expensive and sophisticated instrument for measuring energy expenditure. Resource constraints required that the study be limited the study to six participants. In study one, action ball energy expenditures were contrasted with ACSM recommendations for a bout of exercise. In study two data were analyzed to compare energy expenditure and subjective experience data across three activities: action ball, basketball, and ultimate Frisbee. Students self-selected which of the classes they would register for and were not recruited for any particular activity class. For both studies, at the beginning of the semester, students were presented with the opportunity to participate in the study. They were informed that participation was not required to meet class requirements, their participation or non-participation would not affect their standing in the class, and they were allowed to leave the study at any time; none of the students declined to participate in the study once accepting participation.

Setting

Both studies took place at the Texas A&M University Student Recreational Sports Center and Penberthy Recreational Sports Complex. The gymnasium facility features three regulation size indoor basketball courts. The physical education activity program (PEAP) hosts their indoor basketball courses in this facility. The Penberthy Recreational Sports Complex is the outdoor facility used for teaching outdoor physical education courses. The classes were held on marked artificial turf fields that measured 100x40 yards. The classroom located on the facility is near the playing fields that are equipped with wireless internet, seating, tables for seventy-five people, and whiteboards for instruction. The classes were held in the months of September to December 2016.

Participants

Students in both studies were 18-25 years old. Seventy (64%) were male and 39 (36%) were female. Students were enrolled in one of five sections of PEAP elective classes at Texas A&M University. Each of the five sections was devoted to instruction on only one sport: action ball, basketball, or ultimate Frisbee. Table 1 provides a break-down of the numbers of participants by sex, class, sport (action ball, basketball, ultimate Frisbee) for studies 1 and 2.

The first study (Study 1) generated data that allowed comparison of energy expenditure during action ball with American College of Sports Medicine daily energy expenditure recommendations (ACSM, 2014). Six students participated in the action ball class while using a $K4b^2$ device. That device measures energy expenditure based on expired gases. Energy expenditure is measured through breath-by-breath analysis during the entire duration of participation. Five students in Study 1 were male and one was a female.

All one hundred nine students participated in the second study. That study involved comparison of both energy expenditure and subjective experiences during participation in one of three sports: action ball (n=72), basketball (n=14), and ultimate Frisbee (n=23). Seventy-six of the participants volunteered to provide measures of both energy expenditure and subjective experiences during participation. These seventy-six students wore portable Polar heart rate monitors to measure energy expenditure. The seventy-six students also measured their subjective experiences following the game. Following the end of the game, enjoyment was measured through the PACES self-report questionnaire. Deep structured prevalence, deep structured frequency, and perceived value were also measured. The remaining thirty-three students volunteered to participate only by completing the self-report measures of subjective experiences which include PACES, deep structured prevalence, deep structured frequency, and perceived value.

Table 1: Research Participants

Study 1: *n*= 6 Participants in the Action Ball class using the K4b[2]

Action Ball (AB) (Weekday)	Numbers of Participants using K4b[2]		
	Total	Male	Female
Action Ball (M)	2	2	0
Action Ball (W)	2	2	0
Action Ball (M/W)	2	1	1
Total AB using K4b[2]	6	5	1

Study 2: *n*= 109 Participants in the three classes: action ball, basketball, and ultimate Frisbee

Activity (Weekday)	Numbers of Participants, EEm*			Numbers of Participants, SEm**			Total
	Total EEm	Male EEm	Female EEm	Total SEJm	Male SEm	Female SEm	
Action Ball (M)	17	9	8	6	2	4	23
Action Ball (W)	14	9	5	5	2	3	19
Action Ball (M/W)	21	17	4	9	3	6	30
Basketball (M)	10	9	1	4	4	0	14
Ultimate Frisbee (T)	14	10	4	9	5	4	23
Total	76	54	22	33	16	17	109

Notes. * Energy expenditure measurement **Subjective Experience measurement

Materials

The PEAP provided equipment for all of the sports taught in all five classes. Action ball requires twenty agility cones to mark the crease, two 10x5 feet soccer goals, and a soccer ball. The cones are to mark the twelve-foot crease that surrounds the goal that is located on the field baseline. The field dimensions are 50x40 yards. Ultimate Frisbee requires a field, a 175-gram Frisbee. Traditionally, games are played on a 70x40 yard field with 25 yard end zones. The Penberthy Complex could only accommodate 80x40 yard fields with 10 yard end zones for the ultimate Frisbee class. Basketball requires two basketball goals, a basketball court, and a basketball. The dimensions of the court are 28x16.67 yards.

Procedures Common to both Studies

Both began with the same procedures. On the first day of class, students were informed of the study protocol. After obtaining written informed consent, students underwent familiarization trials with both the energy expenditure and subjective experience measurement tools. Participants who consented to having their energy expenditure measured were assigned a participant code and folder for data collection post class meetings.

The end of the class sessions also followed the same procedure for both studies. All participants completed measures of subjective experience following participation in their respective activity (action ball, basketball, and ultimate basketball). The weeks selected were weeks 5 and weeks 12 for activity days. Week 5 provided ample amount of instruction for all sports to allow students to understand the rules and regulations of a game. It was important for the study that all students understood how the game was played. Week 12 marked the final week of the semester to allow students to participate in a full game.

The classes were all 50 minutes in duration. Schedules were as follows:

Action Ball

Monday (M) 9:10-10:00 Action Ball (AB)-Section 120;

Wednesday (W) 9:10-10:00 AB-Section 120;

Monday/Wednesday (M/W) 10:20-11:10 AB- Section 199;

Basketball

M 8:00-8:50 Basketball (BB) - Section 199;

Ultimate Frisbee

Tuesday (T) Ultimate Frisbee (UF) 11:10-12:00- Section 199

Study 1

Participants, Study 1

The six participants in Study 1 played action ball for the entire 50-minute class period. Participants' ages ranged from 18 to 25 and consisted of both males (*n*=5, 83%) and females (*n*=1, 17%). Students were randomly selected using an excel formula random name generator.

Measurement, Study 1

The Cosmed $K4b^2$ was used to measure energy expenditure in Study 1. The Cosmed $K4b^2$ is a "gold standard" wearable device for measuring energy expenditure (Maiolo et al., 2003; Howley, 2001; Bassett Jr. & Ainsworth, 2001). The retail price for one unit is $43,700. Breath-by-breath analysis yields three dimensions of energy expenditure: METs, Kcal, and heart rate. The device required approximately 90 minutes of preparation time for each day it was used. The device had to be assembled, calibrated, and cleaned. Consistent with established protocol for using the device, the heart rate monitor was applied at the thorax region of the research participant. Details are presented in Appendix A. Subjects and the device also had to be prepared for use once the activity began, a process that required approximately five minutes.

Procedures, Study 1

One participant was randomly selected to wear the K4b^2 device for a particular class period, beginning with the fifth week of the class. These weeks were chosen because class sessions were fully devoted to playing action ball; no skill development drills or instruction regarding rules occurred during these class sessions. The randomly selected participant was fitted with the K4b^2 telemetric gas analyzed for the duration of action ball play for that period. Research assistants applied the equipment within five minutes of the start of the class session and began data collection when dynamic warm-ups started. For data analysis, the data collected during the dynamic warm ups and team selection will be excluded. Games lasted 36 minutes, with four, one-minute water breaks. The lesson plan for these six sessions follows:

1. Dynamic Warm Ups (3:00 minutes)
    a. High knees, butt kicks, leg swings on fence (x15 repetitions for each leg)
    b. Jumping jacks, carioca, walking lunges (20 yards)
    c. Side shuffle, back pedal, A skips, B skips, and accelerations (20 yards)
2. Teams for Games (2:00)
    a. Teams were divided equally for game play.
    b. Players were randomly assigned by giving each student a number.
    c. Students would then find their assigned numbers to make a team.
3. Gameplay (40:00)
    a. Four quarters of nine minutes. Four (1:00 minute) breaks included in between each period. Gameplay would last nine minutes.
    b. Whistle would blow for break and all participants would stop playing and use this opportunity to rehydrate, rest, and collaborate with team members.

c. This process would be repeated three more times.

d. At the conclusion of the activity, the whistle blew three times to indicate end of activity. Research assistants then hit the "stop" button on the device to cease collection of energy expenditure data.

Data Analysis Procedure, Study 1

Data were collected by the $K4b^2$ system on a breath by breath basis. The data were extracted from the participant's $K4b^2$ files and input into an Excel spreadsheet. The data were cleaned, coded, and organized. Incomplete reports were deleted and outliers were removed. Incomplete reports were the reports collected during the calibration portion of the machine before the participant put on the machine.

Physical and physiological characteristics were included to provide a representation of the participants. The cleaned data were exported to the statistical package for social science (SPSS) statistical software version 25. Descriptive statistics, including means, standard deviations, skewness, and kurtosis were completed to evaluate central tendency, dispersion, and shape of the distributions.

H_1 proposed that METs expended through forty minutes of participation in action ball will exceed the ACSM daily recommendations for moderate-intensity physical activity (3.0-5.9 METs). H_2, asserts that a single bout of action ball will produce a number of kcals burned that exceeds the ACSM full-day recommendation for number of kcals burned. The ACSM recommendation is 400 kcals. H_1 and H_2 involved testing METs and kcal against ACSM recommendations for moderate intensity physical activity. Both of these analyses involved calculation of 95% confidence intervals for the variables and noting the status of the respective recommendation relative to the lower limit of the confidence interval. The confidence interval for METS was compared to the ACSM recommendation standard for moderate physical activity during a bout of activity. The confidence interval for kcal was compared to the ACSM recommendation for kcal expenditure per day. Males were analyzed differently because of the limited numbers of the study and the differences in men and women with energy expenditure. Generally, men will burn more calories because men tend to have more lean muscle mass. For these reasons, the two genders were separated during data analysis.

Study 2

Participants, Study 2

Participants in Study 2 included all five PEAP classes (*n*=109). Participants' ages ranged 18 to 25. The sample consisted of both males and females. Participants reported both their subjective experience levels through questionnaires. Energy expenditure was measured through Polar Heart Rate Monitors and H1 heart rate sensors.

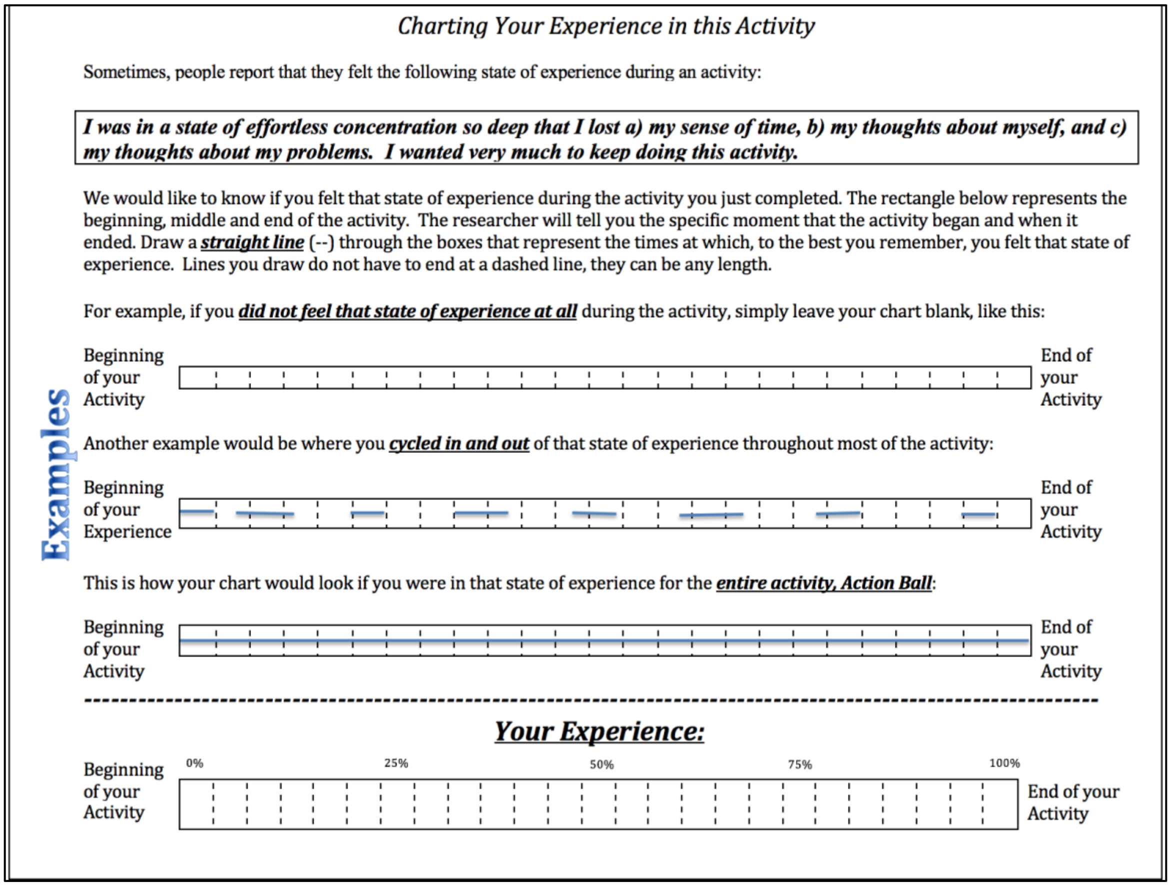
Measurement, Study 2: Subjective Experience and Energy Expenditure

Study 2 involved use of Polar heart-rate monitors and three self-report measures of subjective experience. The self-report measures were the Physical Activity Enjoyment Scale (PACES) (Kendzierski & DeCarlo, 1991), deep structured experience prevalence (DSEp) (Ellis et al., 2017; Ellis et al., 2018), deep structured experience frequency (DSEf), and perceived value of time spent (PVTS) (Ellis et al., 2016). A description of each of these follows.

Polar Heart Rate Monitor: Polar Heart Rate Monitors and H1 heart rate sensors were used to measure energy expenditure (heart rate and kcal expenditure) in Study 2. These monitors were worn on participants' wrists. When synchronized with H1 heart rate sensors, Polar Heart Rate Monitors generate a continuous measure of heart rate and kcal expenditure (Karvonen & Vuorimaa, 1988; Leger & Thivierge, 1988). The H1 heart rate sensors were strapped to participants' chests. Participants' average heart rate and kcal expenditure for the duration of the activity were recorded.

Deep Structured Experience: Deep structured experience was one of three indicators of subjective experience measured and collected through self-report in Study 2. Deep structured experience is defined as a state of effortless concentration during which individuals lose (a) their sense of time, (b) their thoughts about themselves, and (c) awareness of their problems. Participants have a genuine interest in the activity in which they are involved and a strong desire to continue doing that activity (Ellis et al. 2017). Procedures for measuring DSE were identical to those used by Ellis, Freeman, Jiang, and Lacanienta (2018). Research participants were presented a rectangle. The left side of the rectangle represented the beginning of an activity and the right side of the rectangle represented the moment of termination of the activity. Participants were presented with the definition of deep structured experience and asked to draw lines between the two ends of the rectangle to represent the occasions that they were "in" deep structured experience. The sum of the length of all lines drawn (in millimeters) divided by the length of the base of the rectangle served as a measure of DSEp. A measure of DSEf was obtained by counting the number of lines drawn inside the rectangle, as seen in Figure 1 taken from Ellis et al. (2017).

Figure 1: Illustration of the Deep Structured Experience Measurement Tool.


Charting Your Experience in this Activity

Sometimes, people report that they felt the following state of experience during an activity:

I was in a state of effortless concentration so deep that I lost a) my sense of time, b) my thoughts about myself, and c) my thoughts about my problems. I wanted very much to keep doing this activity.

We would like to know if you felt that state of experience during the activity you just completed. The rectangle below represents the beginning, middle and end of the activity. The researcher will tell you the specific moment that the activity began and when it ended. Draw a ***straight line*** (--) through the boxes that represent the times at which, to the best you remember, you felt that state of experience. Lines you draw do not have to end at a dashed line, they can be any length.

Examples

For example, if you ***did not feel that state of experience at all*** during the activity, simply leave your chart blank, like this:

Beginning of your Activity — End of your Activity

Another example would be where you ***cycled in and out*** of that state of experience throughout most of the activity:

Beginning of your Experience — End of your Activity

This is how your chart would look if you were in that state of experience for the ***entire activity, Action Ball***:

Beginning of your Activity — End of your Activity

Your Experience:

Beginning of your Activity — 0% — 25% — 50% — 75% — 100% — End of your Activity

Perceived Value of Time Spent: Perceived value of time spent is a measure of the extent to which participants report contentment with their investment of time to participate in a structured experience (Ellis et al., 2017). That concept was measured using an existing instrument (Ellis et al., 2018). A five-item, Likert-type scale was used. Participants were instructed to "indicate the extent to which you find each of the following to be false (1) or true (5)." Five items were included on the questionnaire:

- This was an excellent use of my time.
- I am glad I chose to do this.
- I made a good choice when I decided to do this.

- I wish I had spent my time doing something else.
- This meeting was worth the time I put into it.

Scores were calculated by assigning a value to each response and summing across the items. The alpha reliability estimate for this scale using a response format ranging from “very strongly disagree to “very strongly agree” has been consistently above .80 (e.g., Ellis, Lacanienta, et al., 2018; Ellis, Taggart, Martz, Lepley, & Jamal, 2016; Lacanienta et al., 2018). In the current study, the alpha reliability coefficient was .862.

PACES: Enjoyment of the physical activity (action ball, basketball, ultimate Frisbee) was assessed by a revised Physical Activity Enjoyment Scale (PACES). PACES was designed to measure positive affect associated with involvement in physical activities in college students (Kendzierski & DeCarlo, 1991). It has demonstrated internal consistency with coefficient α=.90 and item-total correlations ranging from r_{IT}=.38 to r_{IT} =.76 (Crocker et al., 1995). The revision involved converting PACES to a situation-specific measure. The original PACES measures enjoyment of physical activity in general. Participants are asked 15 questions preceded by the stem, “when I am physically active.” To contextualize enjoyment to the activities that were part of this study, participants were asked, “Please rate how you feel at the moment about the physical activity that you have been doing?” A 7-point Likert-type response format is used (I enjoy it—I hate it). A score is computed by calculating the average of the 15 items. Sample items are “I find it energizing,” “It is a lot of fun,” and “I like it.” The alpha reliability coefficient for this adapted scale was .901.

Procedures, Study 2

The first four weeks of the course, the instructor familiarized the participants with the sport rules and health data collections processes. Each energy expenditure participant had a specific code (i.e. 001AB, 01UF, 1BB) and corresponding coded folder with their data sheet located in the classroom area near their activity location. Students arrived before the class began and located their folder to find their specific FT4 Polar heart rate watch and H1 Polar heart rate monitor. The participant received an illustrated instruction sheet on how to wear a heart rate monitor across the sternum in case they had forgotten how to use it. Bathrooms were available for both males and females. Assistants in both genders were available to assist participants. These devices had their age and weight programmed into the device for accurate heart rate collection.

Students only measuring their subjective experience indicators did not need a folder. Both groups were trained on how use the DSE measurement tool. They were shown that they could draw lines inside the rectangular continuum to indicate their overall experience. Participants were free to draw lines as long or as short as needed to represent their deep structured experience. They were also free to draw as many as they wish. Measures of frequency, prevalence, and pattern of deep structured experience are derived from the measure. The participants also were trained to locate the questionnaire using the online Qualtrics survey application via their cellphone or computer.

Beginning on week five of the semester, students began collecting their energy expenditure in all of the classes. The students were able to participate in games with a clear understanding of how the sport operated by this week. This week also marked the first time to collect subjective experience measurements for the participants. All of the PEAP classes followed the same curriculum. The students arrived to class. Participants using the Polar Heart Rate Monitors applied their specific watches and heart rate monitors. All students entered the field or court together approximately five minutes into the class session. The instructor blew the whistle to indicate the start of the activity session. All students clicked the “start” button on the watch to begin collecting their energy expenditure data. The class schedules for energy expenditure and subjective experience measurements (week five and week twelve of the semester) went by the following list:

1. Dynamic Warm Ups (3:00 minutes)
    a. High knees, butt kicks, leg swings on fence (x15 repetitions for each leg)
    b. Jumping jacks, carioca, walking lunges (20 yards)
    c. Side shuffle, back pedal, A skips, B skips, and accelerations (20 yards)
2. Teams for Games (2:00)
    a. Teams would be divided equally for game play.
        i. Action Ball (50x40 yards. 7 people versus 7 people)
        ii. Ultimate Frisbee (100x40 yards. 7 people versus 7 people)
        iii. Basketball (28x16.67 yards. 5 people versus 5 people)
3. Gameplay (40:00)
    a. Four quarters of nine minutes. Four (1:00 minute) breaks included in between each period. Gameplay would last nine minutes.
    b. Whistle would blow for break and all participants would stop playing and use this opportunity to rehydrate, rest, and collaborate with team members.
    c. This process would be repeated three more times.
    d. At the conclusion of the activity, the whistle blew three times to indicate end of activity. Students then hit the “stop” button on their Polar wrist watches to cease collection of health data.

4. Collection of Data

   a. Participants immediately went to the classrooms to measure their DSE. All participants were provided a writing utensil and the deep structured experience continuum scale to measure their experience during the activity.

   b. The research participants then completed a questionnaire using the online Qualtrics survey application that measured PACES and perceived value.

   c. Students wearing Polar watches would record their duration of activity, average heart rate, and total Kcal/match.

   d. Steps A, B, & C were repeated on weeks five and twelve of the semester.

Method of Data Analysis: Study 2

The data were extracted from the Qualtrics and input into an Excel spreadsheet. The data were cleaned, coded, and organized. Incomplete responses were deleted and reverse-worded items were recoded.

The cleaned data were exported to SPSS statistical software version 25. Descriptive statistics, including means, standard deviations, skewness, kurtosis, and standard errors of means were calculated to evaluate central tendency, dispersion, and shape of the distributions. Cronbach's alpha was used to estimate the reliability of the multiple-item measurement instruments. Levene's test of homogeneity of variance was conducted for each of the outcome variables. Graphs of the distributions were examined for degree of conformity with the assumption of normality.

Repeated measures analysis of variance was used to test the significance of the differences among H_3-H_4 energy expenditure means at weeks 5 and 12. Factors in the design were sport (action ball, basketball, ultimate Frisbee) and week (Week 5, Week 12). Separate univariate analyses were conducted for kcal and percent of max heart rate. A full factorial design was used for both of these analyses. The design included the main effects of week (5 vs. 12) and sport (action ball, basketball, and ultimate Frisbee) and the week-by-time interaction. The investigation, though, was focused on differences between action ball and the other two sports. As such the interaction effect was included in the model to reduce error variance, but significant interaction effects were not relevant to the purpose of the study and were thus not interpreted.

Single factor analysis of variance (ANOVA) was conducted to test H_5-H_8 and were tested at a p<=.05 level. Hypotheses 5 through 8 proposed mean differences on measures of enjoyment, perceived value of time spent, deep structured experience prevalence. Significant omnibus *F* tests were followed up with Dunnett’s post-hoc tests. Dunnett’s test contrasts the mean of a designated group (typically a control group) with other groups in the study. Action ball was the reference group in those contrasts; action ball means were compared with means from participation in ultimate Frisbee and basketball. Effect sizes were measured through partial eta squared (η_p^2) ratios.

CHAPTER IV

RESULTS

This chapter presents results of data analysis from two studies. Eight hypotheses were tested across the two studies. Study 1 examined hypotheses 1 and 2. These hypotheses addressed the energy expenditure (METS and kcal, as measured by the $K4b^2$ device) of action ball relative to the ACSM standards. H_1 proposed that METs of action ball participants would exceed the ACSM daily recommendations for moderate-intensity physical activity. H_2 proposed that a single session of action ball would produce a number of kcals burned that exceeds the ACSM full-day recommendation for number of kcals burned.

Study 2 involved testing six hypotheses (H_3-H_8). Hypotheses 3 and 4 addressed the effects of sport on energy expenditure. H_3 proposed that the percentage of max heart rate of action ball participants would be higher than ultimate Frisbee participants and basketball participants. H_4 proposed that kcal expenditure of action ball participants would be higher than ultimate Frisbee participants and basketball participants. Hypotheses 5 through 8 addressed the effects of action ball (vs. basketball and ultimate Frisbee) on subjective experiences: H_5 enjoyment, H_6 perceived value of time spend, H_7 prevalence of deep structured experience, and H_8 frequency of deep structured experience.

Study 1 Results

Descriptive Statistics Study 1

Select physical and physiological characteristics (mean ± standard deviation) for Study 1 participants are summarized in Table 2. Included are age, height, weight, and body mass. The sample of males (*n*=5) had had a mean body weight of 81.55 kg ± 13.12 and the female (*n*=1) participant's body weight was 65.77 kg. The men's body mass index averaged into the "overweight" ACSM category while the female was in the "normal" range.

Table 2: Study 1 Physical and Physiological Characteristics

Variable	Total (*N*=6)	Men (*N*=5)	Women (*N*=1)
Age (years)	20.00 ± .89	19.8 ± .836	21
Height (m)	1.79 ± .041	1.80 ± .031	1.72
Weight (kg)	78.92 ± 13.39	81.55 ± 13.12	65.77
BMI	24.53 ± 3.39	25.02 ± 3.54	22.04

Hypothesis Tests Study 1

H_1 proposed that METs expended through forty minutes of participation in action ball would exceed the ACSM daily recommendations for moderate-intensity physical activity (3.0-5.9 METs). Action ball male participants expended an average of 6.19 METs for a 40-minute game of action ball. The lower bound of the confidence interval was 5.44 METs, and the upper bound was 6.94. The lower bound thus exceeded the ACSM recommendation (3.0 METs). Results suggest a 40-minute game of action ball will exceed the daily moderate-intensity of 3.0-5.9 METs energy expenditure recommendations from the ACSM. The female participant's METs for the activity was 6.10.

Hypothesis 2 asserted that a single bout of action ball would produce a number of kcals burned that exceeded the ACSM full-day recommendation for number of kcals burned. The ACSM recommendation is 400 kcals. The men's sample mean was 385.23 kcals expended during the game. The lower bound of the confidence interval was 353.91 kcal and the upper bound was 416.55. For the hypothesis to be rejected, the lower bound of the confidence interval would be above the ACSM standard, 400. Because the lower bound is less than 400, the null hypothesis was retained: a 40-minute game of action ball does not seem to exceed the daily recommendations of 400 kcals expended. The female participant's kcal expenditure was 295.16.

Study 2 Results

Descriptive Statistics Study 2

Select physical and physiological characteristics for sample of participants in Study 2 are presented in Table 3. The total sample (*n*=76) had a mean age of 20.27 ± 1.17 and a body mass index of 24.95 ± 4.58. The male participants had a higher body mass index (25.76 ± 3.54) while the females had a body mass index of 22.95 ± 3.70. As a group, the ACSM classification of participants was "normal" in regards to their body mass index.

Table 3: Study 2 Physical and Physiological Characteristics

Variable	Total (N=76)	Men (N=54)	Women (N=22)
Age (years)	20.27 ±1.17	20.24 ± 1.25	20.24 ± 1.25
Height (m)	1.76 ± .099	1.80 ± .079	1.80 ± .079
Weight (kg)	77.91 ± 15.82	83.65 ± 13.76	83.65 ± 13.76
BMI	24.95 ± 4.58	25.76 ± 3.54	25.76 ± 3.54

Study 2 Hypothesis Tests, Energy Expenditure (H_3 and H_4)

Analysis of variance results for percentage of max heart rate (H_3) are presented in Table 4. The main effect of sport was significant ($F_{2,73}$=4.38, p=.016, η_p^2=.107). Dunnett's test revealed that ultimate Frisbee produced significantly greater percentage of max heart rate than both action ball and basketball. Hypothesis 3, then, was not supported by the data.

Table 4: Percent Max HR by Sport and Week

Source	Sum of Squares	df	Mean Square	F	η_p^2
Week	.016	1	.016	10.02	.12
Week * Sport	.032	2	.016	9.72	.21
Error (Week)	.119	73	.002		
Sport	.047	2	.024	4.38*	.107
Error (Sport)	.393	73	.005		

Means: Percent of Max Heart Rate

			95% Confidence Interval	
Sport	Mean	Std. Error	Lower Bound	Upper Bound
Action Ball	.75	.007	.74	.77
Basketball	.73	.016	.69	.76
UFrisbee	.79	.014	.76	.81

Dunnett's *t* test

(1) Sport	(2) Sport	Mean Difference (1-2)	Std. Error	Sig.
Action Ball	UFrisbee	-.036*	.015	.021
Basketball	UFrisbee	-.06*	.021	.006

*p<.05

Analysis of variance results for kcal (H_4) are presented in Table 5. The main effect of sport was significant ($F_{2,73}$=10.21, p=.001, η_p^2=.21). Dunnett's test revealed that action ball produced significantly greater kcal expenditure than basketball. However, action ball's kcal means difference was not significantly different than ultimate Frisbee. Hypothesis 4, then, was not supported by the data.

Table 5: Kcal by Sport and Week

Source	Sum of Squares	df	Mean Square	F	η_p^2
Week	4907.01	1	4907.06	2.03	.03
Week * Sport	49625.91	2	24812.95	10.27*	.22
Error (Week)	176350.29	73	2415.75		
Sport	72786.87	2	36393.43	10.21*	.21
Error (Sport)	259997.84	73	3561.61		

*p<.001

<u>Means:</u> kcal

			95% Confidence Interval	
Sport	Mean	Std. Error	Lower Bound	Upper Bound
Action Ball	374.13	5.85	362.46	385.78
Basketball	311.75	13.35	285.15	338.35
UFrisbee	382.21	11.28	359.74	404.69

<u>Dunnett's *t* test:</u> kcal

(1) Sport	(2) Sport	Mean Difference (1-2)	Std. Error	Sig.
Basketball	Action Ball	-62.38*	14.57	.001
UFrisbee	Action Ball	8.08	12.71	.910

*The mean difference is significant at the .05 level

Hypothesis Tests Study 2, Subjective Experiences, Week 5

Means and hypothesis tests associated with the Week 5 data are presented in Table 6. Only one subjective experience variable, deep structured experience frequency (DSEf), varied significantly by sport. Dunnett's test revealed that the ultimate Frisbee DSEf mean was significantly higher than the action ball mean. The difference between DSEf for basketball and action ball was not significant.

Partial eta squared (η_p^2) values for all subjective experience variables were negligible-to-weak. These ranged from .014 (DSE prevalence) to .103 (DSE Frequency). Action ball sample means for PACES were indicative of participants enjoying the activity as much as the other sports. Action ball showed a score of 5.24 out of 6. Basketball reported a score of 4.75 and ultimate Frisbee was 5.13.

Table 6: Study 2 Week 5 Hypothesis Tests

	Means				
Variable	Action Ball	Basketball	UFrisbee	F	η_p^2
PACES	5.24	4.75	5.13	2.61	.05
Perceived Value	4.67	4.44	4.66	1.46	.03
DSE Frequency	1.57	2.53	2.90	5.33*	.10
DSE Prevalence	.88	.85	.81	.66	.01

*p<.05

Dunnett's *t* test: Week 5 Hypothesis Tests

Dependent Variable	(1) Sport	(2) Sport	Mean Difference	Std. Error	Sig.
DSE Frequency	UFrisbee	Action Ball	1.36*	.43	.003
DSE Frequency	Basketball	Action Ball	.965	.53	.07

*The mean difference is significant at the .05 level

Hypothesis Tests Study 2, Subjective Experiences Week 12

Hypothesis test results (i.e., H_5-H_8) from week 12 are summarized in Table 7. Significant sport effects were found for both deep structured experience prevalence (DSEp) [H_7;$F(2,87)$ =6.49, p=.002] and DSEf (H8 ;F (2,87) =14.99, p<.001). Dunnett's t-tests revealed a significant difference between action ball and basketball (p<.001), with participants in action ball averaging .90 ± .13 and basketball averaging .72 ± .22. There was a significant difference in DSEf between action ball and basketball (p<.01) with participants in action ball averaging 1.27 ± .55 and basketball participants averaging 4.00 ± 4.07.

Table 7: Study 2 Week 12 Hypothesis Tests

	Means				
Variable	Action Ball	Basketball	UFrisbee	F	η_p^2
PACES	5.35	5.00	5.64	3.27	.07
Perceived Value	4.60	4.47	4.83	1.58	.03
DSE Frequency	1.27	4.00	1.25	14.99*	.25
DSE Prevalence	.90	.72	.92	6.49*	.13

Dunnett's *t* test: Week 12 Hypothesis Tests

Dependent Variable	(3) Sport	(4) Sport	Mean Difference	Std. Error	Sig.
DSE Prevalence	Basketball	Action Ball	-.17*	.05	.01
DSE Prevalence	UFrisbee	Action Ball	.021	.04	.885
DSE Frequency	Basketball	Action Ball	1.08*	.42	.01
DSE Frequency	UFrisbee	Action Ball	-.021	.40	.74

*p<.05

Summary of Results

Table 8 provides a summary of the results of the hypotheses tests. Overall, action ball elicited levels of energy expenditure at levels recommended by the ACSM (2014) and high levels of quality experiences in comparison to basketball and ultimate Frisbee. In Study 1, results indicated that for the limited sample tested a 40-minute game of action ball will exceeded the daily moderate-intensity of 3.0-5.9 METs (H_1). The null was retained for hypothesis 2 because action ball did not exceed the daily kcal expenditure recommended by the ACSM.

Study 2 examined the effects of action ball's percentage of max heart rate, kcal expenditure, and subjective experiences compared to basketball and ultimate Frisbee (H_3-H_8). Percentage of max heart rate (H_3) was not supported by the data; the percentage of max heart rate of action ball was lower than ultimate Frisbee. H_4 revealed that action ball produced greater kcal expenditure than basketball, but not ultimate Frisbee. PACES (H_5) and perceived value of time spent (H_6) results indicated that of action ball indicated levels of quality experience, but were not significantly different from basketball and ultimate Frisbee. DSEp (H_7) was the only subjective experience measure to have significance in week 5. In week 12, however, DSEp (H_7) and DSEf (H_8) reported a significant difference between action ball and basketball.

Table 8: Hypotheses Results

Hypothesis	Result
H_1: METs of action ball participants will exceed the American College of Sports Medicine daily recommendations for moderate-intensity physical activity.	Study 1: null rejected
H_2: A single session of action ball will produce a number of kcals burned that exceeds the ACSM full-day recommendation for number of kcals burned.	Study 1: fail to reject the null
H_3: The percentage of max heart rate of action ball participants will be higher than ultimate Frisbee participants and basketball participants at both weeks 5 and week 12.	Study 2: fail to reject the null
H_4: The kcal expenditure of action ball participants will be higher than ultimate Frisbee participants and basketball participants at both weeks 5 and week 12.	Study 2: fail to reject the null
H_5: Enjoyment of action ball participants will be higher than ultimate Frisbee participants and basketball participants.	Study 2: fail to reject the null
H_6: Perceived value of time spent of action ball participants will be higher than ultimate Frisbee participants and basketball participants.	Study 2: fail to reject the null
H_7: Prevalence of deep structured experience of action ball participants will be higher than ultimate Frisbee participants and basketball participants.	Study 2: null rejected
H_8: Frequency of deep structured experience of action ball participants will be higher than ultimate Frisbee participants and basketball participants.	Study 2: null rejected

CHAPTER V

DISCUSSION AND CONCLUSION

The purpose of this study was to examine the energy expenditure and subjective experiences of action ball relative to two popular sports taught in physical education classes in the United States: basketball and ultimate Frisbee. The measures of energy expenditure included percentage of max of heart rate (%Max HR), kilocalories (kcal), metabolic equivalent of tasks (METs). Subjective experience measures included the Physical Activity Enjoyment Scale (PACES), deep structured experience prevalence, deep structured experience frequency, and perceived value of time spent.

Two studies were conducted. The first study (Study 1) generated data that allowed comparison of energy expenditure during action ball with American College of Sports Medicine daily energy expenditure recommendations (ACSM, 2014). Six students participated in the action ball class while using a $K4b^2$ device. The second study (Study 2) involved comparison of both energy expenditure and subjective experiences during participation in one of three sports. The collection of data occurred in weeks 5 and week 12 of the semester.

Results of Study 1 showed that participating in forty minutes of action ball exceeded the daily ACSM recommendation of 3.0-5.9 METs. Action ball did not, however, yield kcal expenditures above the ACSM standard. In Study 2, action ball produced significantly higher kcal expenditure levels than basketball. Percentage of max heart rate did not vary significantly between action ball and the other two sports.

Action ball produced lower frequency of deep structured experience than ultimate Frisbee at Week 5, indicating higher quality of subjective experience. At Week 12, action ball produced significantly lower frequency of deep structured experience than basketball and significantly greater deep structured experience prevalence than basketball. Other measures of subjective experience quality did not vary significantly across the three sports.

Energy Expenditure Results

Energy expenditure was collected by the Cosmed $K4b^2$ machine and FT4 series Polar Heart Rate Monitors with H1 heart rate sensors. The $K4b^2$ machine automatically calculates total energy expenditure and energy expenditure rates using an equation in its program. This equation is based off of the Weir equation (Schrack et. al., 2010) and uses oxygen consumption and carbon dioxide production (exhalation) to estimate the amount of energy used. The FT4 Polar Heart Rate Monitors with H1 heart rate sensors are a high rated product from Polar (Hongu et al., 2013). Those devices come with chest straps and wristwatches. This monitor transmits the data from the chest strap to the wrist watch in coded form. Coding prevents any kind of interferences from other devices; thus providing accurate readings that belong to the participant.

Using these devices, results of this study suggest that participation in action ball may meet recommended levels by the ACSM of energy expenditure. Energy expenditure in action ball is at least commensurate with basketball and ultimate Frisbee, and energy expenditure in action ball may exceed that of basketball and ultimate Frisbee during some competitions. Metabolic equivalent of task (MET) is a common way the health and sport industry to reports intensity of an activity. National health publications have reported that a moderate intensity MET (3.0-5.9METs) is required for adequate health benefits to be acquired from activities. The MET_{mean} of 6.18± .22 during a 40-minute game of action ball exceed the daily moderate-intensity of 3.0-5.9 METs energy expenditure recommendations from the ACSM. Action ball can be considered as a moderate-vigorous activity (3.0-5.9, > 6.0 METs) (Ainsworth et al., 2011). Kcal expenditure per activity session is a great target point for individuals who exercise

(ACSM 2014). Based on the findings from Study 1, the $kcal_{mean}$ 370.225 ± 17.61 using the $K4b_2$, one session of action ball per day is equivalent to 92.5% of the ASCM guidelines (400 kcals) for energy expenditure. Heart rate is another gauge of intensity as well as a way of estimating energy expenditure in other activities (Karvonen & Vuorimaa, 1988). In Study 2, the FT4 Polar heart rate monitors recorded the mean percentage of maximum heart rate as .747 ± .056 for a 40-minute activity session. This mean is within the ACSM recommended 55 to 85 percent of maximum heart rate and a longer duration than the recommend session of at least 20 to 30 minutes. Action ball participants consistently remained within the 74 percent of their max heart rate during both bouts of playing. The FT4 Polar heart rate monitors recorded the mean of 360.40 ± 51.14.

In Study 2, the results for energy expenditure differed for kcal per match and percentage of maximum heart rate. Action ball produced greater kcal expenditure than basketball, but it did not yield higher percentage of max heartrate than basketball (or ultimate Frisbee). This inconsistency requires analysis and interpretation. Perhaps most importantly, kcal and percentage of max heart rate are related, yet very different indicators of energy expenditure. From a statistical perspective, correlations between these two variables was .64 at Week 5 and .42 at Week 12. Much stronger correlations would be expected, of course, if both kcal and percentage of max heartrate were simply different measures of a common phenomenon.

The differences between energy as measured by the two approaches is evident from consideration of the nature of the competition. Both kcal and percentage of max heart rate become less reliable in the absence of steady-state exercise. The two bouts of competition did not yield steady state heart rate exercise. Heart rate is linearly correlated to energy expenditure during steady state exercise. A higher steady state heart rate produces more energy than a lower steady state heart rate. For example, if two participants are running a mile and both are at the same weight but different fitness levels. Both participants run the mile at the same pace and burn the same number of kcals, but experience different intensity levels. Heart rate does not necessarily mean more kcal expended, but it can identify different intensities. During gameplay for all sports, the participants did not have a steady state heart rate during gameplay. The games involved sprinting, jogging, walking and sprinting again. The ability, therefore, to use the measurement of heart rate to calculate caloric expenditure is not as reliable when it comes to non-steady state exercise. The FT4 Polar Heart Rate Monitors considers weight, height, movement, heart rate, and steps to estimate the expended energy in an exercise bout. The reason for using the FT4 Polar watch is to have the results of this study to be generalizable to what the public is using to track fitness. The public is not using metabolic portable carts to measure oxygen consumption when participating in sport. The results show action ball is just as equal as basketball and ultimate Frisbee in regards to meeting activity recommendations. A generalization can be made from the descriptive statistics that show action ball participants can burn just as many calories in Week 5 as Week 12. For example, players that have played the sport for the first time can burn as many calories as when they have been trained for up to twelve weeks. This cannot be said about the other two sports in Study 2.

Overall in Study 2, common ways to measure energy expenditure were to record both kcal and percentage max heart rate. Caloric measurements were used because many fitness recommendations are based on caloric intake and expenditure. Moreover, percentage of max rate was used because it is a very common exercise training modality for the general public. The results from Study 2 showed significant differences with kcals and percentage of max heart rate. The results show that action ball participants will burned similar or more kcals between basketball and ultimate Frisbee. The non-consistent significance among energy expenditure results between kcal and percentage of maximum heart rate can be addressed by the FT4 Polar watch algorithm and non-steady state heart rate. First, the FT4 Polar watch uses an algorithm to produce caloric expenditure that factors in more physiological reactions than heart rate. Secondly, the reliability issue of non-steady state heart rate predicting caloric expenditure is evident during these activities.

Limitations Energy Expenditure

The study had some limitations, which would suggest caution when generalizing the results to the population at large. The sample size for the portion of the study that used the $K4b^2$ during the structured 40-minute activity sessions of action ball included only six individuals (5 males and 1 female).

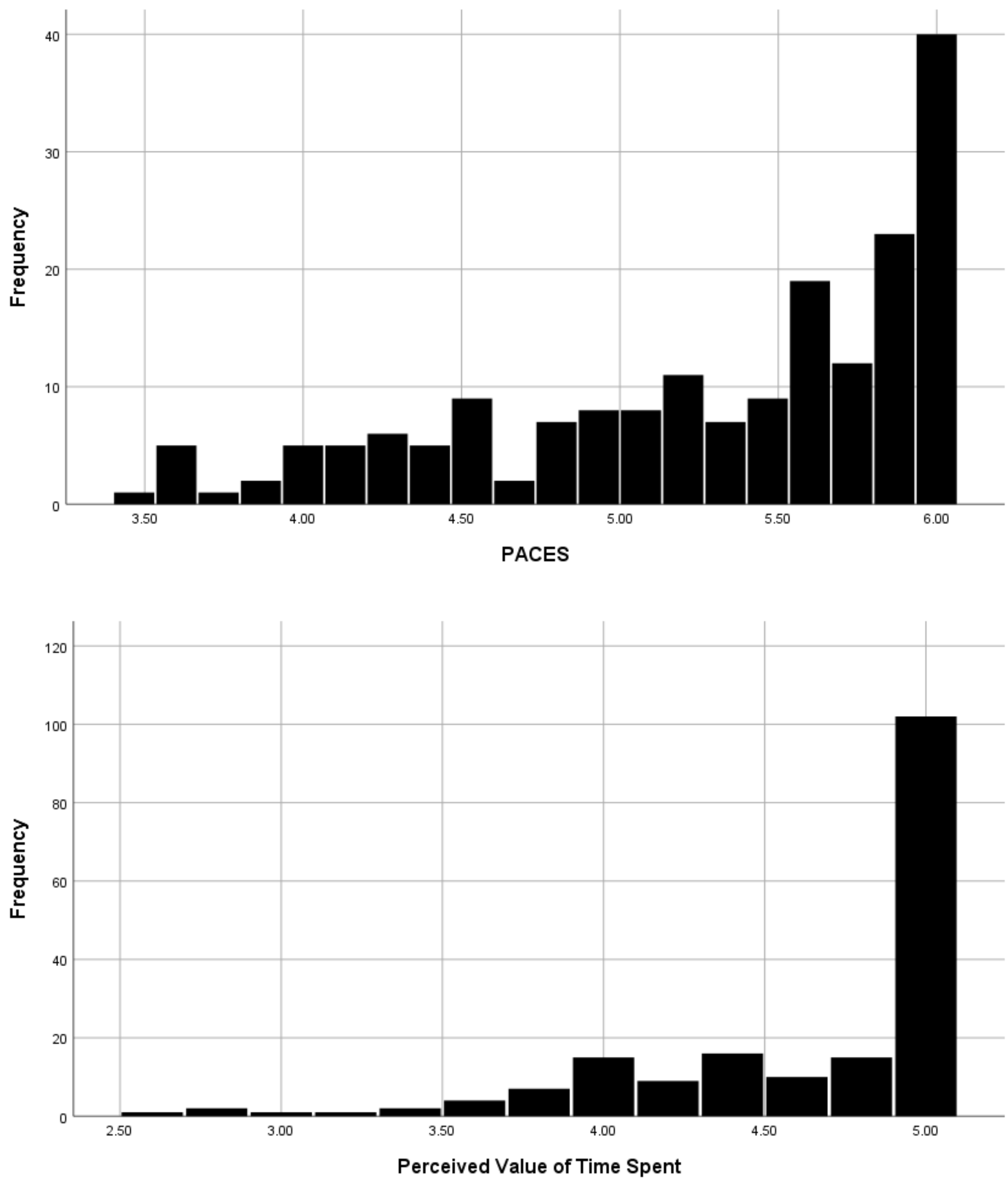
METs, Kcal, and HR also has some limitations as a method of describing exercise intensity and estimating the energy expenditure of action ball. A large person would be expected to have a larger resting oxygen uptake compared with a smaller person. Energy expenditure values for a given activity can vary not only according to body size, but also level of fitness, skill, and whether or not the activity is performed in a competitive situation. Heart rate results could also be impacted by stress levels, caffeine, or other outside factors that can affect heart rate. Results could also be affected by various environmental conditions, such as cold, heat, humidity, wind, altitude, playing surface, and terrain, as well as clothing and equipment worn. No effort was made to collect data about these factors or include this kind of data in the data analyses. Even with these limitations, the energy expenditure measurement indicators represent simple, practical, and easily understood procedures for expressing energy expenditure of action ball. Their utilization provides a convenient method to describe the functional capacity of an individual or group during a bout of exercise. In summary, the use of wearable sensor technology is useful for quantifying the physiological demands of action ball. This information can provide critical insight for the benefit of a new physical education game.

An additional limitation was the number of participants in the basketball and ultimate Frisbee classes. For study 2, the sample sizes for these courses were smaller than action ball for Study 2.

Subjective Experiences Results

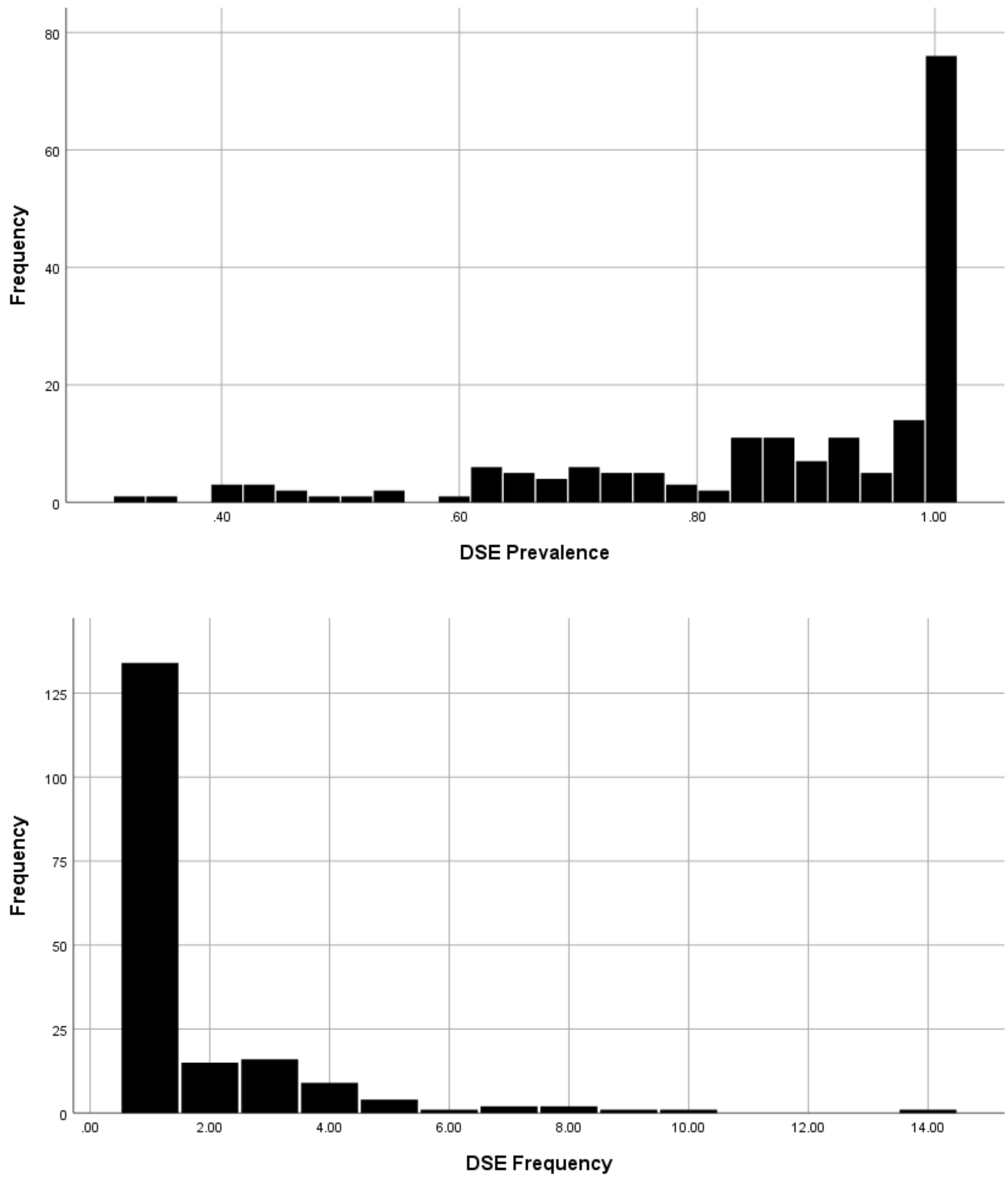
No significant difference was found in PACES and perceived value of time spent means. A compelling explanation for the non-significant results is that a ceiling effect was present; participants deeply enjoyed participation in all three sports. As Figure 2 reveals, both of these variables exhibited notable negative skewness, with the greatest frequency of scores (i.e., the greatest density) occurring at the highest possible scores. For PACES, 22% of responses were at the highest possible score, and 55% of responses were at the highest possible perceived value of time spent score; thus, a need exists for measures that will yield greater variation in measures of the quality of experience while participating in these sports. Future research should use more sensitive methods of measuring intensity of enjoyment and intensity of perceived value of time spent. Magnitude scaling (Lodge, 1981), which involves calibrating adjectives describing different intensities of phenomena via psychophysics, has excellent potential as an approach to solving this problem of limited variation.

Figure 2: Distributions of PACES and Perceived Value of Time Spent



The measures of deep structured experience prevalence and frequency (Figure 3) have even greater skewness. For both of these measures, the greatest frequency of scores was as the extreme end of the range of possible responses. (Recall that lower scores on deep structured experience frequency reflect higher experience quality). For deep structured experience prevalence, 75 of the 185 responses (41%) were at 100% prevalence. For deep structured experience frequency, 134 of the185 responses (72%) were at the lowest possible value (i.e., 0), thus, the ceiling effect was problematic for evaluating differences in deep structured experience across the three sports. The skewed data indicates that the two activity sessions were highly positive or valued. A solution to this limitation may include using different indicators of experience quality.

Figure 3: Distributions of DSE Frequency and DSE Prevalence



It could be argued that the skewed data should have been transformed prior to calculation of the test statistics. If an appropriate transformation could be found, distributions might have approached normality; a fundamental assumption of the distribution of the sampling distribution of the *F* statistic. Maxwell and Delaney (2004), however, present a compelling argument against using transformations. They point out that, while suitable empirical distributions may result from various transformations, practical interpretation of results of analyses of data based on those distributions becomes incredibly complex. In applied disciplines such as education, business, and recreation, park and tourism sciences, this observation is particularly important. In the case of these data, for example, reporting the percentage of time participants were in a state of deep experiences using the raw data is fully intuitive. Interpreting results following a cube-root of that percentage is not at all intuitive.

Bayesian theory provides an alternative method of analysis that is not based on the assumption that the underlying distribution is normal. Through that approach, “credible intervals” may be calculated. Credible intervals closely resemble the “confidence intervals” often calculated using traditional frequentist methods. They are calculated from posterior density of a probability distribution. The range of scores in a credible interval has a known probability of containing the parameter of interest (Lambert, 2018). Table 9 summarizes subjective experience data using this Bayesian approach. As that table reveals, action ball produced significantly lower DSEf than ultimate Frisbee at Week 5, and lower DSEf than basketball at Week 12. Action ball also produced higher DSEp than basketball at week 12, but not at Week 5. While the Bayesian approach resolves the problem of violation of assumption of normality, the substantive significance of the results is largely unchanged, compared to the frequentist approach reported in the results chapter. Action ball sometimes yields significantly less DSEf than basketball and ultimate Frisbee during some periods of gameplay, and does not in others.

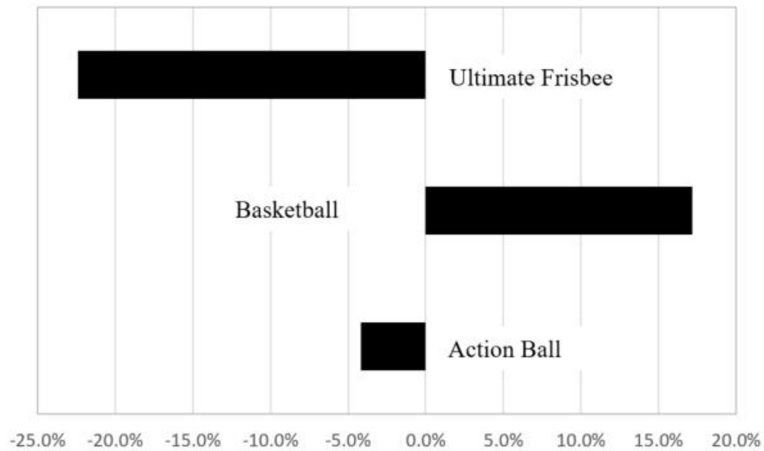
Table 9: Bayesian Analysis of Subjective Experience Data

Variable	Week	Posterior Means Action Ball (AB)	Basketball (BB)	Ultimate Frisbee (UF)	95% Credible Interval Differences
DSEfreq	5	1.57	2.54	2.91	AB<UF
DSEfreq	12	1.27	4.00	1.25	AB<BB; UF<BB
DSEprev	5	.87	.85	.82	
DSEprev	12	.90	.73	.93	AB>BB
PACES	5	5.24	4.75	5.14	
PACES	12	5.35	5.01	5.64	
PVTS	5	4.68	4.45	4.66	
PVTS	12	4.60	4.47	4.83	

Regardless of the approach taken to significance testing, the differences in results regarding deep structured experience prevalence and frequency from Week 5 and Week 12 is notable. At Week 5, action ball produced lower frequency of DSE than ultimate Frisbee, but not at Week 12. At Week 12, action ball produced lower frequency of DSE than basketball and a greater DSE prevalence than basketball (but not ultimate Frisbee). One explanation for this result is changes in the number of naturally occurring interruptions in the flow of activity in gameplay on any given day. There are interruptions that generally occur in sport. For example, during a bout of action ball participants could experience a player getting injured or the ball flying out of the playing field boundaries. These breaks in the gameplay are inherit aspects of sport. Future research in DSE may utilize multiple game sessions to better understand the effect of interruptions that occur during a structured experience. Though these results varied in Week 5 and Week 12, the data show action ball DSE prevalence and frequency means were consistently in the direction indicative of higher quality experience.

Another exploratory analysis that may provide useful insight into the data involves scrutiny of variation in subjective experience scores from Week 5 to Week 12. If the assumption that action ball affords opportunity for participants with a greater variety of skill sets to succeed (as argued in the rationale section), variation in subjective experience scores from Week 5 vs. Week 12 would be lower for action ball than ultimate Frisbee and basketball. As Figure 4 shows, data are consistent with that assumption. The average change in standard deviations is much lower in action ball than both basketball and ultimate Frisbee. Thus, the leptokurtic and skewed distributions of means across the set of subjective experience variables suggests participants were deeply engaged in all three sports, but the small standard deviation for action ball indicates a more consistent experience in that sport. This result does not, of course, confirm the proposition about skill sets, but it is notable that the data are consistent with that proposition.

Figure 4: Average Percent Change in Standard Deviations of Subjective Experience Measures; Week 5 vs. Week 12



Data from the study contribute to knowledge about the theory of deep structured experience (Ellis, Freeman, Jamal, & Jiang, 2019). Although the theory proposes an inverse relation between deep structured experience prevalence and deep structured experience frequency, that proposition has not previously been tested. In Study 2, the correlation between these two variables was -.50 (p<.001) at Week 5 and –.61 (p<.001) Week 12. Thus, results provide support for a proposition of theory of structured experience. It appears when a structured immersion experience is interrupted, deep structured experience frequency increases. During a game, sports will have interruptions with fouls, violations, and the sport's object rolling out of bounds. Sport may provide a rich and appropriate setting for research on deep structured experience frequency.

Overall, results support the position that action ball, basketball, and ultimate Frisbee are immersive sports, and each results in high levels of energy expenditure. Participants report enjoying the sport, valuing their time spent in playing the sport, and being in deep experience while playing the sports. Thus, it would appear that such sports have an appropriate place in physical education programs.

Subjective Experiences Data Limitations

With regard to subjective experience data, there were some study limitations. The lack of activity sessions and limited number of participants may have had confounding effects on the study. Additionally, external elements may have affected the participants as well. For example, each activity session occurred on a different day. The elements of the outdoor setting for ultimate Frisbee and action ball could have impacted participant responses. Some of the elements include temperature, wind, and others. Field experiments will almost always include extraneous variables that may have confounding effects. Participants' actions outside of the meeting time could have had an effect on their experience. For example, Week 5 participants may have rested very well the day before the activity session. Week 12 participants could have had very poor rest resulting in physiological effects that could impact their experience. This example is one of many daily experiences participants engaged in that could have a confounding effect on the subjective experiences of the sport. Therefore, future research may examine standardizing variables within participants in an effort to avoid this issue.

Another limitation was the low number of participants in basketball and ultimate Frisbee. The association strengths (effect size) for subjective experiences techniques were weak, suggesting that future research with those techniques might require larger sample sizes to show statistical significance. Additionally, the subjective experiences data recorded in Week 5 and Week 12 were not linked with the physical activity results and with each other. Due to missing this link, an opportunity analyzing an interaction was not available. A solution for this issue is to have participants mark their surveys with a given code to connect the different sessions.

Threats to Validity

In order to execute efficiency, it is important to examine possible threats to internal and external validity. Internal validity is the extent to which an effect observed in an experiment can be attributed to the independent variable, as opposed to some other extraneous cause. External validity is the extent to which observed effects may generalize beyond the participants in the study.

Campbell and Stanley (1963) published a seminal work on validity of inferences researchers can make about results of an experiment. In the years following, different researchers have revised the list and extended the concepts of validity to include such facets as "ecological validity" (Gall & Borg, 1983) and statistical conclusion validity (Maxwell, Delaney, & Kelly, 2018). Borg and Gall suggested expanding the original list of threats to internal validity to ten: a) history, b) maturation, c) testing, d) instrumentation, e) statistical regression, f) differential selection, g) attrition, h) selection-maturation interaction, i) The John Henry effect, and j) experimental treatment diffusion. Privitera (2017) identified four categories of threat to external validity: population validity, ecological validity, temporal validity, and outcome validity.

The most notable threats to validity include testing validity, ecological validity, instrumentation, attrition, and extreme variability of participants.

- Testing is a concern because of the multiple occasions of data collection. The participants could have increased comfort levels with equipment and not placed equipment on as efficient as the first time when being instructed. There is not a concern for subjective experiences because the questionnaire was only completed twice with weeks separating them.

- Ecological validity is a concern for this study due to the fact of the environmental changes throughout the study. Distractions during class time could affect the participation of the student during an activity. The weather also has an influence on the participation from the students in the class. The basketball class was the only class with a controlled indoor environment each week, while the other classes had to manage the changing temperatures throughout the semester. It can be argued that the instructor provided a different style of instruction for each class to influence the participants. It is notable that the Department of Health and Kinesiology require mandatory evaluation of instructors. These evaluation scores will be included as a measure of instructor influence towards the participants.
- Extreme variability of participants is a potential threat to ecological validity for this type of study. It is not possible to control each participants' interest in the class, skill, or motivation to participate in general. Bronfenbrenner (1992) illustrates the complexity of environmental contexts that impact youth. Students could attend class disengaged because of outside stressors, influences, and concerns.

Future Research

This study provides foundation for instituting future research on the health and experience quality of action ball. Health benefits are associated with playing action ball for forty minutes. Additionally, this study adds to the body of literature for the theory of structured experience (Ellis et al., 2017). Measurements of enjoyment, immersion, and perceived value of time spent are also associated with activity. Future researchers could link the two phenomena for more conclusive evidence that enjoying action ball leads to health benefits.

If this study were to be replicated, specific would be a few adjustments with how the study is conducted would be needed. There would need to be more action ball, basketball, and ultimate Frisbee 40-minute gameplay days throughout the study. Also, it would be ideal to have more individuals in each class. For the measurement of enjoyment, future researchers could use a magnitude scaling-based approach instead of PACES. Assuming the participants are naturally going to be in DSE, this measure should probably not be included. All three sportshave shown to be engaging; therefore, it would not be an effective measurement of quality experience because the participants max out on DSE. Future researchers should also try to use magnitude scaling for perceived value of time spent. The adjustments for energy expenditure would be to use the $K4b^2$ for all participants in the multiple gameplay settings. This would be expensive, but would likely result in more measurements of energy expenditure across the three sports. Additionally, the week 5 and week 12 subjective experience results bring to mind the unpredictability of sport. Action ball and ultimate Frisbee seemed to improve their overall quality experience while basketball reported the opposite. With more play days and additional subjective experience measurements, one could assume that participants in sport are not guaranteed a certain experience because sport is unpredictable.

It may also be important to note the importance of comparing action ball to other physical activities that are dissimilar to action ball. Examples of these activities include golf, cycling, boxing, and other activities people participate in during recreational time. This could provide a comparison to team-based sports to generally individual sports. Rather than rejecting the null, it may be appropriate to use "prove the null" as an alternative when comparing activities like action ball to other comparable sports. It is not the case to see which is better, but rather if it is comparable. An article by David Streiner in the *Canadian Journal of Psychiatry* provides a resource for this type of work. Streiner (2003) explains that often within the context of comparing something new with something that is already established, the new intervention is not inferior to the standard. This "prove the null" approach can be explained as equivalence or noninferiority testing that could show that one treatment is not significantly worse than another.

Conclusion

The participation of action ball for forty minutes can elicit moderate-to-vigorous levels of physical activity and report high levels of quality experience. The purpose of this study was to examine the energy expenditure and subjective experiences of action ball relative to two popular sports taught in physical education classes in the United States: basketball and ultimate Frisbee. The participation of action ball for forty minutes can elicit moderate-to-vigorous levels of physical activity and report high levels of quality experience. While PACES and perceived value of time spent were not significant, this study provided new insights to measuring enjoyment levels during physical activity.

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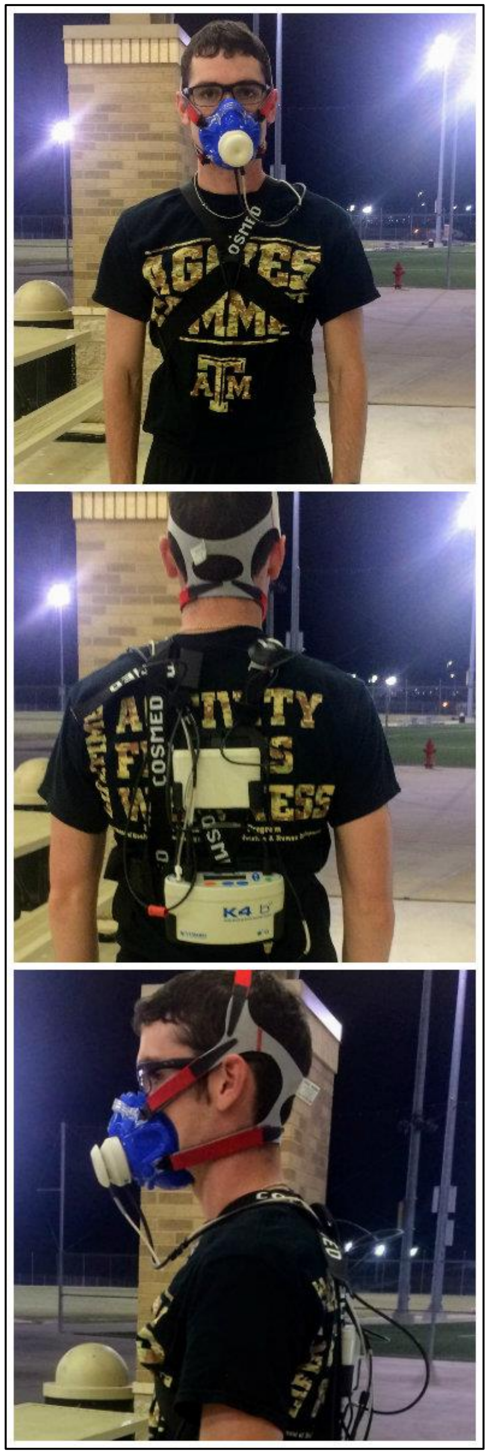
APPENDIX A

STUDY 1 K4b^2 MACHINE



APPENDIX B

K4b^2 MACHINE ASSEMBLY

For equipment assembly, the operator arrived 1.5 hours prior to subject testing time. The K4b^2 was turned on and allowed a 45 minutes warm up time prior to calibrating and subject testing. The mask and flow meter were assembled by plugging a sanitized turbine into the mask adapter by pushing and rotating clockwise. The optoelectronic reader was then placed over the turbine and attached to the mask. The wind cover was applied over the flow meter and the sampling line placed in the optoelectronic reader hole designated for the sampling line. The turbine cable was then attached to the control panel of the K4b^2 portable unit (PU).

Three calibration tests were completed prior to each subject test. The first calibration was for the turbine. The calibration syringe, a 3000 ml syringe is attached to the optoelectronic reader. With the PU attached to the computer the option “calibration” was chosen from the main screen and “turbine calibration” was selected. The syringe was operated by pulling and pushing the plunger, the display showed expired and inspired readings for the strokes of the syringe. When “calibration done” appeared the operator checked for inaccurate readings and the turbine was calibrated. If discrepancies were detected, sampling line and the portable unit were checked for problems and the test was run again

Room air calibration required the operator to remove the sampling plug from the flow meter. In the main menu, with the PU still linked to the computer, “calibration menu” was selected and the option “room air calibration” was selected by pressing enter. The display showed O_2 and CO_2 values for room air and a message of “Do not breathe near the sampling line” was displayed until the calibration was over. When “calibration done” appeared; the readings were checked for inaccuracies and the calibration was complete. If discrepancies were detected, sampling line and the PU were checked for problems and the test was run again. Reference gas calibration required a gas cylinder containing a ratio of 16% O_2 to 5% CO_2. The sampling plug was again removed from the flow meter and calibration menu opened. Within the calibration menu reference gas calibration was chosen. The first part is a room air calibration similar to the Room air calibration sequence, the sampling plug remained open to room air. The display then read “sample reference gas”, the sampling line is plugged into the calibration unit which is the connection of the portable unit and the gas cylinder. At the end of the procedure “calibration done” was displayed and the numbers were checked against reference numbers for discrepancies. If discrepancies were detected, sampling line and the portable unit were checked for problems and the test was run again.

Every 2 weeks the operator completed a delay calibration. The calibration menu was again opened and the O_2/CO_2 delay calibration option was selected. A room air calibration occurred first in this calibration sequence, the sampling line was removed from the flow meter until the “connect sampling line and press enter” appeared on the display. The sampling line was connected to the flow meter attached to a testing mask. The operator then pressed enter and began breathing at a constant rate in synch with the beeping the PU emitted. After some cycles the values for the delay calibration appeared and were checked for discrepancies. If discrepancies were detected the sampling line and the portable unit were checked for problems and the test was run again.

After each use the equipment was cleaned and sanitized for the comfort and safety of the participants. The head cap, Velcro, harness and HR monitor were all soaked in hot soapy water. All except the HR monitor were soaked for 20 minutes. The HR monitor was dipped in hot soapy water and then dried with a towel, to prevent water damage to the sensor contained inside. The head cap, Velcro, harness and HR monitor were air dried or towel dried. The turbine was submerged in a 10% bleach solution for a minimum of 5 minutes and a maximum of 20 minutes. The turbine was then removed from the bleach solution and completely submerged in clean water in another container, several times. The turbine was then laid out to air dry. The turbine was considered dry and ready for use when there were no water droplets on the inside. The masks were sanitized by being submerged in water in a crock pot on low heat for 20 minutes. The masks were then laid out to air dry.

Once the mask and flow meter were assembled and the $K4b^2$ unit calibrated for the protocol, the participant was prepared for carrying of the equipment (see Figure 2). The heart rate monitor was a belt applied at the thorax region of the subject. The elastic strap of the HR belt was adjusted to fit tightly around the thorax with buckles interlocking on the sides that created a snug but comfortable fit. Once the HR belt was applied underneath the subjects clothing the harness was then put on the subject. The harness allowed both the control unit and the battery back to sit in the upper back region of the subject with the battery rested between the shoulder blades and the control system right below. The harness applied over the subject's head was buckled and tightened to fit snugly and securely. The $K4b^2$ unit was then fixed into the designated holders to ensure security of the machine during the class. The heart rate and temperature probe cable as well as the GPS receiver were plugged into the PU, the HR and temperature probe to the HR-Temp probe on PU and the GPS cable applied to the RS232 port on the bottom of the PU. The Settings were changed in "External device" to GPS to initialize GPS for the test.

The mask and head cap were then applied to the subject's face. The subject was asked to hold the mask over the nose and mouth while the tester applied the head gear by snapping the 4 elastic bands to their holders found on either side of the mask. The mask and head gear were applied so that there was a strap above and below the ear on each side. The elastic bands of the head cap were adjusted to create a tight seal around the subject's face without causing discomfort. The subjects riding helmet was applied over top of the head gear and adjusted for safety and comfort.

After calibration and subject preparation was concluded the software was prepped for telemetric data transmission. The receiver unit for telemetry was connected to the recording computer (PC) with a serial cable. In the control panel of the $K4b^2$ transmission was enabled by choosing "transmitter ON" in the "settings" menu. The asterisk was moved to "transmit on" and press enter. On the PU control panel, the operator entered the patient's data by going to the "test" menu and choosing "patient's data". The values were modified to match the subject's individual data including ID, age, height, weight, sex and predicted HR max which is calculated automatically based on age. The computer software was opened on the PC and a patient data dialog box was selected. The patient data for the subject was opened in the software and "Start test" on the PC was chosen. Once the test was started on the PC, the sampling line was unplugged from the mask and "start test" was selected from the "test" menu on the PU control panel. The relative humidity from a portable weather station was entered for "humidity" and enter was pressed. A room air calibration began, the sampling line remained unplugged and away from expired air until "calibration done" appeared on screen. The sampling plug was then connected to the optoelectronic reader in the mask and enter was pressed to allow a check of parameters such as HR or VO_2. The enter key was pressed again to begin storing of data. The operator checked to confirm that all parameters of interest were displaying in the breath by breath display on the PC including GPS parameters.

The subject was then allowed to begin participating in the class. The operator selected the exercise button on the main screen of the PC software to indicate that exercise started, as well as allow GPS speed and distance to begin being collected and displayed. The test was ended by pressing cancel and then enter on the PU.

The participant's data set was opened in the software and "Start test" on the PC is chosen. Once the test was started on the PC, the sampling line was unplugged from the mask and start test was selected from the "test menu" on the PU control panel. The relative humidity from a portable weather station (enter company) was entered for "humidity" and enter was pressed. A room air calibration began, the sampling line remained unplugged and away from expired air until "calibration done" appeared on screen. The sampling plug was then connected to the optoelectronic reader in the mask and enter was pressed to allow a check of parameters such as HR or VO_2. The enter key was pressed again to begin storing data. The operator checked to confirm that all parameters of interest were displaying in the breath by breath display on the PC including GPS latitude and altitude.