KNOWLEDGE, ATTITUDES AND PRACTICES OF PLYOMETRICS AMONG HIGH SCHOOL SPORTS COACHES IN HARARE PROVINCE ZIMBABWE

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FORMAT OF THE DISSERTATION

This dissertation forms part of a supervised Masters degree by research. University rules allow the submission of such degrees in two formats, viz., the traditional dissertation or in manuscript format in order to facilitate the publication of work emanating from higher degrees. The manuscript format is to be structured as one or more published papers of which the student is a prime author, published or in press in peer-reviewed journals approved by the Board of the relevant School, or manuscripts written for publication in a paper format, accompanied by introductory and concluding integrative material.

Accordingly this dissertation is not written in traditional format, but instead ***follows the approved structure of the publication and manuscript format*** and comprises introductory material (chapter 1), an ***already published paper*** (chapter 2), a second ***draft manuscript paper*** (chapter 3) reporting results of original research and concluding integrative material (chapter 4).

DECLARATION

I, Ms Ireen Munekani, student number 214584065, declare:

1. That the work described in this thesis has not been submitted to UKZN or any other tertiary institution for purposes of obtaining an academic qualification, whether by myself or any other party.
2. That my contribution to the project was my own unaided work.
3. Signed_____________________Date _____________________

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ABSTRACT

Strength and conditioning is an important component of athletic success. However, in an African context, strength and conditioning practices are often overlooked. For coaches to effectively implement strength and conditioning programmes, and plyometric training in particular, with their athletes they must address several important training factors which implies that they should be knowledgeable in the implementation of the program. A coach may hold a positive attitude about plyometric training, but if the understanding of the fundamentals of how it functions and improves performance then consistency in the program is not pronounced or translated into strength and conditioning practices. The purpose of this study was to systematically review the role of concurrent strength and endurance training in endurance running and to examine the knowledge, attitudes and practices of plyometrics among high school sports coaches in Harare Province, Zimbabwe. The study design comprised: i) a systematic review of professional peer-reviewed journal publications in the literature using Pubmed, Medline, Science Direct, Ebscohost, Biomed, CINAHL, Embase and Google Scholar as search engines; and ii) a questionnaire-based KNAP descriptive survey among males and female high school coaches (n=100) from 45 schools in the Harare province of Zimbabwe. Results from the systematic review showed that concurrent strength training and endurance running improves the running endurance of endurance runners, without impacting on their VO_{2max} and LT. Combined core strength training and running had contradictory findings regarding the benefits for enhanced running performance. The use of strength training as a protective measure against musculoskeletal running injuries has shown to be a worthwhile intervention. The results from the survey indicated that high school coaches in Harare Province of Zimbabwe, are typically between 30 to 39 yrs of age, with between 5 and 15 years of coaching experience and are mostly male. Slightly more than half (54%) of the coaches let their athletes perform plyometrics. While almost all of the coaches (95%; $p \leq 0.0001$) have previously participated competitively themselves, very few (11%; $p \leq 0.0001$) have previously done plyometrics themselves and the majority (94%; $p \leq 0.0001$) have not had any formal training in plyometrics. With the exception of coaches with training in sport science, who scored an average of 65% for a 20 item knowledge test on plyometrics, generally the coaches have very poor knowledge with regards to plyometric strength training exercise. Although male coaches knowledge was better than that of females and those with 5-15 years of experience had better knowledge than those with more than 15 years of experience, overall the coaches only managed to score an average of 35% for the same a 20 item knowledge test on plyometrics, and accordingly there is a resistance to the practice of using plyometrics more often in the training of their athletes.

KEY WORDS: plyometric training, exercise, warm up, knowledge, attitude

CHAPTER ONE: INTRODUCTION

Introduction

1.1 *Literature Review*

Plyometrics is a method of developing explosive power (Radcliffe and Farentinos, 1999). These exercises improve the working of the neuromuscular system and have been shown to improve overall exercise performance. Most of the literature to date on plyometric training has been focused on the lower limbs because all movements in athletics involved a repeated series of stretch shortening cycles. Adaptation of the plyometric principles can be used to enhance the specificity of training in other sports or activities that require a maximum amount of muscular force in a minimal amount of time (Prentice, 2011). The role of the core muscles of the abdominal region and the lumbar spine in providing a vital link for stability and power cannot be overlooked. Plyometric training for these muscles can be incorporated in isolated drills as well as functional activities (Prentice, 2011).

Plyometric training is an established technique for enhancing athletic performance but may also facilitate beneficial adaptations in the sensorimotor system that enhances dynamic restraint mechanisms and corrects faulty jumping or cutting mechanics, thus reducing the chance for lower extremity injury such as anterior cruciate ligament tears (Plowman and Smith, 2009). Using plyometric training in a safe and correct manner has been shown to produce many positive results such as increased jump height, development of muscle power and increase muscular endurance (Kraemar et al, 2002).

Coaches may be aware of plyometrics and how they can be used to help benefit athletes, but may not know how to perform them safely and implement them effectively into their team work outs. A research that was done by Pote and Christie (2016) indicated that although some forms of conditioning, workload monitoring and injury prevention were being implemented, the correct practices were not being administered. Furthermore, it was identified that most coaches had insufficient qualifications and experience to administer the correct training techniques. It was concluded that coaches require further education so that scientifically based training programs can be implemented. Some online programmes or courses that are offered by the American Council on Exercise (ACE), the International Sports Sciences Association (ISSA) and the National Strength and Conditioning Association of America (NSCAA) can help high school coaches to improve on their coaching and training with regards to plyometric training and other strength and condition training programmes. Kraemer et al (2002) states that there are multiple training programs that are readily available to high school coaches, but an exhaustive search of the literature examining the extent at which coaches use plyometrics effectively and safely when training their athletes is still widely unknown.

Attitudes also influence training or coaching patterns among coaches. Consistency is most likely when the behavior in question is in line with a subjective norm, our view of how important figures in our life want us to act. Conflicts between attitudes and subjective norms may cause coaches to behave in ways that are inconsistent with their attitudes (Kraus, 1995) Thus for example, a coach who believes that plyometric training is good for improving athletic performance may not be out in the open for this view because it might not go well with other coaches who have not tried the plyometric training program.

Attitude consistent behavior is more likely when coaches have perceived control, the belief that they actually perform such behavior (Madden et al, 1992). A coach may hold a positive attitude about plyometric training but if the belief is not there that it improves performance then consistency in this program is not pronounced. Direct experience with plyometrics increases the likelihood of attitude consistent behavior. If your positive attitude towards plyometrics is based on having actually been involved in the plyometric training program you are more likely to adhere to plyometric training than if your attitude stems solely from imagining plyometric exercises (Madden et al, 1992).

Plyometric exercise has been proven to increase muscle output, power, endurance and vertical jump height as well as decrease the risk of injury (Bompa, 2005). Several studies have shown that plyometric training improves the running economy and also leg strength in athletes (Mackenzie, 2014).

Reference	Methods and Sampling	Results
Spurs et al. 2003	17 male endurance runners were randomly divided, the experimental group completing a plyometric programme for 8 weeks and their normal running, while the control group completed their normal running.	The improved RE facilitated a faster 3km time trial performance, but without a corresponding alterations in VO_2max and LT.
Turner et al. 2003	18 trained endurance runners were randomly divided with the experimental group completing a plyometric programme for 6 weeks and their normal running and the control only their running.	6 weeks of plyometric training improved the RE in trained endurance runners; however this ergogenic effect is undetermined.
Saunders et	7 well-trained endurance runners	Plyometric training can improve the RE in well-

al. 2006	completed a plyometric training programme for 9 weeks, 3 sessions/week, in addition their normal running, while 8 well-trained runners only completed their normal running.	trained runners without changing their VO_2max.
Faigenbaum et al. 2007	13 athletes were doing a combined plyometric and resistance training program .	The addition of plyometric training to resistance training program maybe more beneficial than resistance training combined with static stretching
Kumar et al. 2014	40 intercollegiate hockey players underwent plyometric and yogic practices for 12 weeks.	The results supported the theory that plyometric training with yogic practices improve skill performance such as dribbling, control, shooting accuracy and overall playing ability.
Santos and Jeneira 2008	25 male athletes had a 10 week in season training: control and complex training (weight training and plyometrics).	The complex training group improved in all 4 explosive tests and the control group decreased in all tests except one.

Table 1.1 Results from the previous studies

For coaches to effectively implement plyometric training with their athletes they must address several important training factors which implies that they should be knowledgeable in the implementation of the program. Knowledge however is a familiarity, awareness or understanding of something such as facts, information, descriptions or skills which is acquired through experience or education by perceiving, discovery or learning. According to the Oxford Dictionary (American English), knowledge can refer to a theoretical or practical understanding of a subject. It can be implicit (as with practical skill or expertise) or explicit (as with theoretical) understanding of a subject. According to Elbaz (1981,1983) practical knowledge is a complex, practically oriented set of understandings, which a coach actively uses to shape and direct the work of coaching. In examining teachers' knowledge Elbaz (1981,1983) identified the following component of practical knowledge: knowledge of subject matter, knowledge of curriculum, knowledge of instruction and knowledge of self.

Plyometric type exercises have been used successfully by many coaches as a method of training to enhance power in athletes. The review by Slimani et al (2016) shows a greater effect of plyometric training alone on jump and sprint performance. They went on to recommend the use of a well-designed and sport specific plyometric training programme as a safe and effective training modality for improving jumping and sprint performances as well as agility in team sport athletes. Reviews by Bobbert and also by Lundin and Berg cited in Markovic (2007) concluded that plyometric training is effective in improving vertical jump ability. Several studies have shown that plyometric training improves overall performance of athletes (Mackenzie, 2014). A study on the knowledge, attitudes and practices of plyometrics among coaches and athletes has not been done in Zimbabwe, so the researcher having noted this gap in literature was motivated to do this study.

1.2 *Research Objective*

The purpose of this study was to: i) systematically review the literature on the role of concurrent strength and endurance training in endurance running; and ii) to survey the knowledge, attitudes and practices of plyometrics among high school sports coaches in Harare Province, Zimbabwe.

1.3 *Survey Research Questions*

1. What are the demographics of high school coaches with respect to age, gender, coaching experience and educational qualifications and training?
2. What is the prevalent attitude, practice and knowledge-base of high school coaches with respect to plyometric training?
3. Is there a difference in plyometric knowledge, and practices between coaches of different gender at the high school level?
4. Is there a difference in plyometric knowledge, attitudes and practices between coaches based on number of years coaching?
5. Is there a difference in plyometric knowledge, attitudes and practices between coaches based on their qualifications and educational training?

1.4 Definition of Terms

1.4.1 Plyometric Training

This is a type of training that involves explosive movements such as jumping, bounding or hoping in different directions or places of movements which activates eccentric muscle contraction. (Spurs et al. 2003)

1.4.2 Exercise

Exercise is a sub category of physical activity, according to Caspersen et al (1985) exercise is a physical activity that is planned, structured, repetitive and purposive in the sense that improvement or maintenance of one or more components of the physical fitness is the objective.

1.4.3 Warm Up

Warm up is designed to elevate core body temperature. Warmup consists of active or passive warming of body tissues in preparation for physical activity. Active warm up consists of low-intensity movements that are effective in elevating body temperature, warming tissue and producing a variety of improvements in physiological function. Passive warm up includes external heat sources like heating pads, whirlpools, or ultrasound. Prior to vigorous exertion, athletes should perform several minutes of general body movements of progressively increasing intensity. These movements should emulate the actual movements of the sport or exercise to follow. Warm up benefits performance through thermal, neuromuscular and psychological effects (Bishop D, 2003).

1.4.4 Knowledge

Knowledge however is a familiarity, awareness or understanding of something such as facts, information, descriptions or skills which is acquired through experience or education by perceiving, discovery or learning.

1.4.5 Attitude

An attitude is a tendency to think, feel or act positively or negatively towards objects in our environment. According to Rosenburg and Hovland (1960), attitudes are "predispositions to respond to some class of stimuli with certain classes of response". These classes of responses are:

- Affective:-what the person feels about the attitude object (plyometric exercise), how favorably or unfavorably it is evaluated.
- Cognitive:-what the person believes the attitude object (plyometric exercise) is objectively.
- Behavioral:-how a person actually responds or intends to respond to the attitude object (plyometric exercise).

2. Methods

2.1 Introduction

This chapter expands on the methods used during the study to reach the research aim and objectives. The sample population, the inclusion and exclusion criteria are explored and the instrument used to obtain the study results is discussed. The chapter also looks at the ethical issues regarding the research and reflects the research process that was followed during the study.

2.2 Research Design and Setting

The study design comprised: i) a systematic review of professional peer-reviewed journal publications in the literature using Pubmed, Medline, Science Direct, Ebscohost, Biomed, CINAHL, Embase and Google Scholar as search engines; and ii) a questionnaire-based knowledge, attitudes and practices (KNAP) descriptive survey among males and female high school coaches, in the Harare province of Zimbabwe.

The dependent variables of the survey were coaches' knowledge, attitudes and practices of plyometric exercise. The independent variables of this survey included the coaches' gender, their years of experience and their educational training.

2.3 Participants and Recruitment

Respondents in the survey were high school sports coaches (n=100) in the Harare Province, Zimbabwe. The purposive sample comprised of head sports coaches and their assistants in high schools (n=45) in Harare. Ethical clearance was obtained from the University of KwaZulu-Natal Humanities and Social Sciences Research Ethics Committee (Ref HSS/09851/017M). The participants were informed of the objectives of the study (Appendix A) and were guaranteed confidentiality and anonymity of the data collected. Participants participated voluntarily and signed written consent forms (Appendix B) before participating in the survey. Gatekeeper permission was sourced from the Zimbabwean Ministry of Education Sports Department (Appendix C).

2.3.1 Inclusion / Exclusion Criteria

The following inclusion criteria was used to determine the eligibility of the coaches for the survey sample:-

- Head sports coaches and their assistants in high schools.
- Coaches that understand and speak English.
- Coaches who work at public or private schools.
- Coaches of either gender.
- Coaches with a minimum of 6 months coaching and teaching experience.
- Sports coaches who work at high schools classified as special needs schools, were not included.

2.4 *Instrumentation*

No validated tools were found that could be used to assess the coaches' knowledge, attitudes and practices of plyometrics. A questionnaire (Appendix D) designed by the researcher and adapted from Rucci (2012) was administered. The questionnaire consisted of open-ended, semi-open ended and closed questions. The survey had demographic questions and questions pertaining to plyometric training. These questions were based on published literature on plyometrics (Rucci, 2012, Ellapen et al, 2013). The questionnaires were distributed at training sites just before the sessions and collected as soon as they were completed. Some questionnaires were left to the disposal of Head Coaches for the coaches who were absent and were collected after they were completed.

2.5 Statistical Analysis

Descriptive statistics of nominal frequencies and relative frequency percentages were applied on all data and the inferential chi-square statistic was used to compare dependent categorical responses. The probability was set at $p \leq 0.05$ to interpret significant differences between sub-sets of data (Thomas et al., 2011).

CHAPTER TWO: PUBLISHED MANUSCRIPT

As published in the African Journal for Physical, Health Education, Recreation and Dance (AJPHERD), Volume 21 (1): pp 45-58, 2015.

DOES CONCURRENT STRENGTH AND ENDURANCE TRAINING IMPROVE ENDURANCE RUNNING? A SYSTEMATIC REVIEW

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This systematic review examined the effects of concurrent strength and endurance training in relation to running economy (RE), maximal oxygen consumption (VO_{2max}) and lactate threshold (LT). In addition, the examination of combined core-strengthening and endurance running and the use of strength training to protect endurance runners from musculoskeletal running injuries. The authors' complied with PRIMSA guidelines. The outcome interest was concurrent strength training and endurance running, exposure was endurance runners. Seven electronic databases were searched for publications meeting the following inclusion criteria; concomitant strength training and endurance running ranging from 2003-2013, with 48 relevant publications being identified. These were assessed for quality resulting in 25 English published articles; however 15 intervention and two review studies were used. Concurrent strength training and endurance running improves the RE of endurance runners, without impacting on their VO_{2max} and LT. Combined core strength training and running had contradictory findings regarding the benefits for enhanced running performance. The use of strength training as a protective measure against musculoskeletal running injuries has shown to be a worthwhile intervention. It is recommended that future prospective randomized controlled studies using large samples, longer interventions, and completion times of 10km, 21.1km and 42.2km be used to determine the success of concurrent strength and endurance training.

Keywords: concurrent strength training, endurance running

Introduction

Endurance runners are always searching for new ergogenic training regimes to enhance their performance. The traditional training regimes that precipitated successful marathon performance have been aerobic in nature, which is supported by the principle of specificity of training (Midgley et al., 2007). Popular aerobic training techniques include long distance runs at moderate pace, short tempo runs, high intensity time trials, interval training, fartlek and recovery runs (Midgley et al., 2007). Maximal oxygen consumption (VO_{2max}), lactate threshold (LT) and running economy (RE) are primary factors that influence endurance running (Midgley et al., 2007). Most, elite marathon runners', exhibit similar VO_{2max}, LT and RE values, suggesting that other factors play an important role in facilitating a winning performance (Noakes, 2005).

In the last forty years a debate has risen on the impact of concurrent strength and endurance training concerning endurance running performance. Some evidence suggest that concurrent strength and endurance training facilitates enhanced running performance (Guglielmo et al., 2008; Storen et al., 2008), while other studies indicate no gains being made from the aforementioned cross-training (Robert et al., 2004; Ferrauti et al., 2010). In the absence of definite literature, this review can provide direction to runners whether concurrent strength training enhances running performance.

The purpose of this review is to examine the growing body of literature regarding the impact of concurrent strength and endurance training on running performance in regards to VO_{2max}, LT and RE. The inclusion of the Jung (2003) and Yamamoto et al. (2008) reviews ensured the synthesis of previous literature. The Jung (2003) review included studies on sedentary subjects because of the lack of literature pertaining directly to runners. The inclusion of these studies affected the homogeneity of the population that was examined, and the conclusion drawn must therefore be interpreted with caution when applying to endurance runners. Jung (2003) identified 17 studies that consisted of, runners (2), cyclists (1), rugby players (1) and cross country skiers (2) while the remaining 11 involved untrained subjects. Yamamoto et al. (2008) review comprised of five studies pertaining strictly to highly trained endurance runners. The conclusions drawn by Yamamoto et al. (2008) are therefore specific to highly trained runners, and cannot be inferred to recreational runners. This review included both recreational and trained runners to provide information that may be applicable to all runners.

This review paper identified 15 studies as tailored to concurrent strength and endurance training involving runners. The novelty of this review is the examination of the concurrent strength training as a preventive measure to running injuries. It incorporated randomized controlled trials and review studies that investigated concurrent strength training on endurance runners and triathletes, the latter being included as they are proficient endurance runners and multi endurance sport athletes.

Methodology

The authors followed the standard practices for systematic reviews (PRIMSA). The definitions were guided by the PRIMSA checklist for participants, interventions, comparisons, outcomes and study designs (PICOS). The participants were endurance runners; the intervention was not necessarily a therapeutic intervention but is interpreted as an exposure, namely endurance runners concurrently strength trained and the comparison in various articles were specific to endurance runners and tri-athletes. The outcomes of interest were (i) concurrent strength and endurance running in relation to RE, VO_2max and LT, (ii) concurrent plyometric and endurance running in relation to RE, VO_{2max}, LT, (iii) concurrent core strengthening and endurance running, and (iv) impact of concurrent strength training and endurance running to prevent and rehabilitate running musculoskeletal injuries. The exclusion criteria were (i) publications prior 2003, and (ii) studies of concurrent strength training and endurance running pertaining to non-endurance runners and/or triathletes.

A literature search of peer-reviewed and professional journal publications was conducted, in the following search engines: Pubmed, Medline, Science Direct, Ebscohost, Biomed, CINAHL, Embase and google scholar (Figure 1). Key search words were runners, plyometrics, strength training, concurrent strengthening and endurance running, therapeutic interventions to running injuries. The inclusion criteria for publication selection were endurance runners and/or triathletes.

Results

Forty-eight English publications were identified, however after the exclusion criteria were applied; only 15 were included in this review. Table 1 describes concurrent strength and endurance training in relation to VO_{2max}, LT and RE. Table 2 describes the effects of concurrent plyometric and endurance training in relation to VO_{2max}, RE and LT. Table 3 describes concurrent core strengthening and endurance running. Table 4 describes concurrent strengthening as a preventative measure against running injuries. The term strength training in this review will refers to traditional resistance strengthening, circuit training and plyometric/explosive training.

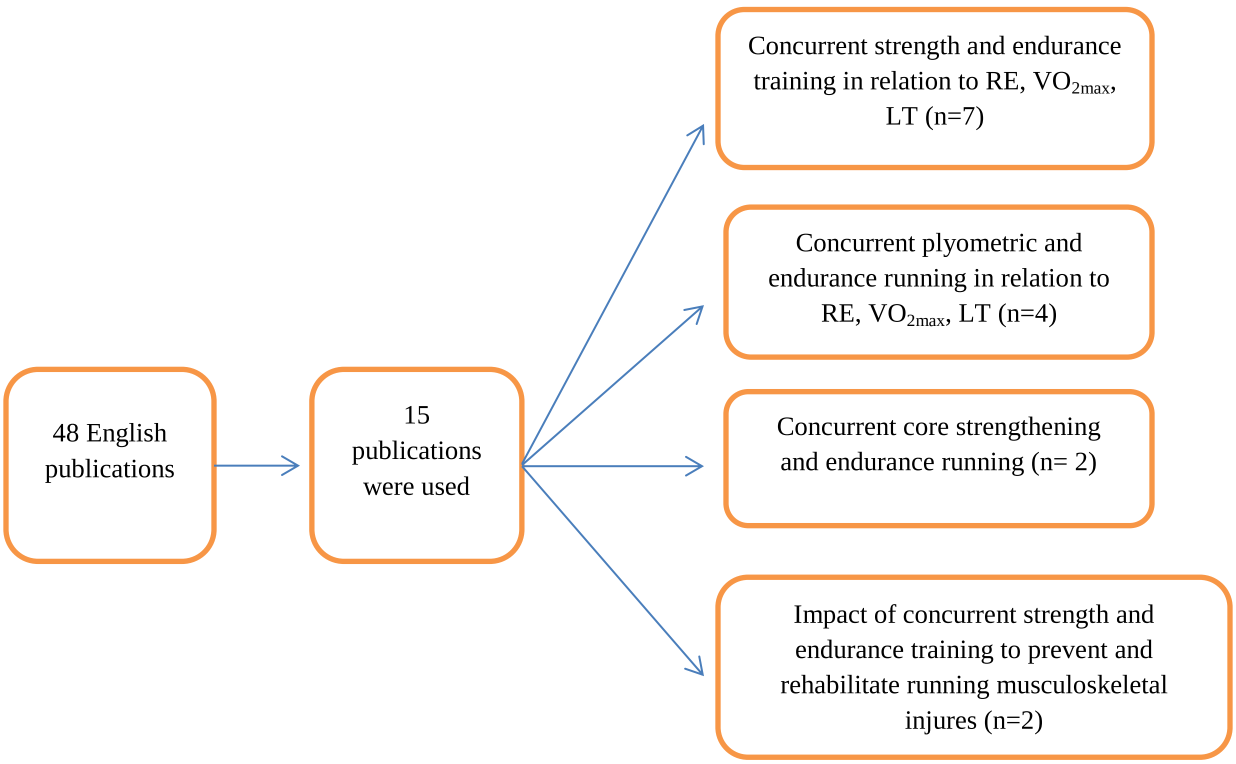

Figure 1. Selection process of the literature review

Table 1. Concurrent strength and endurance training in relation to RE, VO_{2max} and LT.

Study	Participants	Training type	Outcome measure	Findings
Chtara et al.(2005)	48 male trained athletes (mean age 21.4±1.3 yrs.) were divided into five homogenous groups.	Four groups participated in various training programmes for 12 weeks (two session per week); endurance running (E), strength circuit training (E+S), combined strength and endurance (S+E) and endurance (E) and strength (S).	Training produced improvements in 4km time trial for the E+S than the E,S+E and S groups:8.6%, 5.7%, 4.7% and 2.5% respectively ($p<0.01$). Similarly VO_{2max} changed 13.7% (E+S), 10.1% ((E), 11.0% (S+E) and 6.4% (S) ($p<0.01$).	Circuit training immediately after endurance running in the same session produced greatest improvement in 4km time trial and VO_{2max} compared to either running and/or strength training.
Guglielmo et al. (2008)	16 well-trained runners were randomly divided into two groups; heavy resistance training (HRTG) and explosive strength training (ESTG). Runners' mean age, body mass and height were 27.4±4.4 yrs., 62.7±4.3kg and 1.66±0.5m respectively.	HRTG (n=7) completed lower limb strength training in addition to their normal running, while ESTG (n=9) completed explosive strength training (plyometric) in addition to their normal running. Both groups trained 2 additional sessions per week for 4 weeks.	The intervention produced changes in RE in HRTG: 47.3±6.8 to 44.3±4.9ml.kg.min^{-1} ($p<0.05$). The RE of ESTG changed from 46.4±4.1 to 45.5±4.1ml.kg.min^{-1} ($p>0.05$). HRTG VO_{2peak} remained unchanged from 3.7±0.3 to 3.7±0.4L.min^{-1}. Similarly ESTG VO_{2peak} did not change 3.6±.3 to 3.6±0.3 L.min^{-1}.	Traditional strength training improved the RE among well trained runners without impacting on VO_{2max}. When comparing plyometric training to traditional strength training, the latter seems to be more efficient for improvements in RE
Storen et al. (2008)	17 runners were randomly divided into experimental (n=8)	The experimental group completed lower limb strength	The intervention improved the experimental	Concurrent strength training improved 1RM and RE among

	and control (n=9) groups. Experimental group's mean age, body mass and height were 28.6±10.1 yrs., 60.3±9.3kg and 1.7±0.9m. Control group's mean age, body mass and height were 29.7±7.0 yrs., 71.1±12.0kg and 1.7±0.8m.	training and their normal running. The control group completed their normal run training. The experimental group completed 3 additional strengthening sessions per week for 8 weeks.	group's 1RM (73.4±20.5kg to 97.8±21.3kg) and RE (0.67±0.03 to 0.64±0.03 ml.kg.min$^{-0.75}$) by 32.5% and 5% respectively ($p<0.05$). VO_{2max} remained unchanged ($p>0.05$). Control group's 1RM and RE remained similar ($p>0.05$).	well-trained endurance runners without impacting on their VO_{2max}.
Ferrauti et al. (2010)	22 trained recreational endurance runners (8 females and 14 males) were randomly divided into and experimental or control group of 11 each. Runners age, body mass index were; 40.0±11.7 yrs., 22.6±2.1kg.m^{-2} respectively.	The experimental group completed a concurrent trunk and lower limb strength and endurance running programme for 8 weeks. The control group completed the running programme.	Experimental group's VO_2max changed from 52.0±6.1 to 54.9±4.4 mLkg.min^{-1} ($p>0.05$).	8 weeks of concurrent strength and running programme does not improve VO_{2max}.
De Souza et al. (2011)	11 male runners participated in a cross over study (during the control phase, runners strength trained and ran 5km intermittently versus experimental phase were they strength trained and ran 5km continuously).	In the experimental phase they performed 5 controlled repetitions of 5RM x 5sets of leg press and 5km run continuously). In control phase the performed 5RM x 5sets of leg press	During the experimental phase VO_{2max} changed from 45.0±5.2 to 47.7±9.6mL.kg.min^{-1} ($p>0.05$), while during the control the change was 46.6±6.1 to 47.1±6.9mL.kg.min^{-1} ($p>0.05$).	High intensity strength or low intensity strength training before aerobic exercises does not impair endurance performance.

	Runners' age, body mass, height and VO_{2max} were 23.1±3.1 yrs., 1.75±0.07m, 70.5±8.8kg and 58.2±8.3mL.kg.min^{-1} respectively	and 5km run, performed intermittently (1 min run alternated with 1 min rest).		
Doma & Deakin, (2013)	12 trained runners, mean age, height, body mass and VO_{2max} were 23.4±6.4 yrs., 1.8±0.1m, 75.0±8.2kg and 62.5±6.0mL.kg.min^{-1} respectively.	Runners performed strength and endurance training sessions 6 hours apart with running performance tests conducted following day.	RE was calculated such that VO_2 was expressed relative to body mass to the power of 0.75 per (mL.kg.min^{-1}). RE pre-test and post-test measures were 0.7mL.kg.min^{-1} ($p>0.05$).	Running economy is impaired 6 hours following a strength training session. Combined strength and endurance training on the same day appears to cause an accumulation effect of fatigue which impairs running performance the following day.
Piacentini et al. (2013)	16 endurance runners were randomly assigned to maximal strength training (MST) group (n=6) or a resistance training (RST) group (n=5), or a control (C) group (n=5). MST, RST and C groups age were 44.2±3.9, 44.8±4.4 and 43.2±7.9 yrs. respectively.	MST and RST groups' strength trained explosively and traditional in addition to running, while the control ran.	MST, 1RM and RE increased by 16.3% and 6.1% ($p<0.05$). No changes emerged from the other groups ($p>0.05$).	The maximal strength training group significantly improved their strength and RE.

Table 2. Concurrent plyometric and endurance running in relation to RE, VO_{2max}, LT

Study	Participants	Training type	Outcome measure	Findings
Spurs et al.(2003)	17 male endurance runners were randomly divided into an experimental and control group.	The experimental group completed an 8 weeks concurrent plyometric and running programme. The control completed a running programme	The concurrent plyometric and run training improved the experimental group's 3km performance and RE by 2.7% ($p<0.05$). However both groups VO_{2max} and LT remained unchanged ($p>0.05$).	The improved RE facilitated a faster 3km time trial performance, but without a corresponding alterations in VO_{2max} and LT.
Turner et al. (2003)	18 trained endurance runners were randomly divided with the experimental and control group. The cohort's mean age was 29.0±7.0 yrs.).	The experimental group completed a concurrent plyometric and running programme for 6 weeks. While the control only ran.	The concurrent plyometric and running programme improved the experimental group's RE ($p<0.05$). The control group's RE remained unchanged ($p>0.05$).	6 weeks of plyometric training improved the RE in trained endurance runners; however this ergogenic effect is undetermined.
Saunders et al. (2006)	15 well-trained endurance runners were randomly divided into an experimental (n=7) and control (n=8) group. Cohort's mean VO_{2max} was 71.1 $mL.kg.min^{-1}$	The experimental group completed a plyometric training programme for 9 weeks, 3 sessions/week, in addition their normal running, while the control only completed their normal running.	Plyometric training improved the experimental group's RE by 4.1% and lower limb muscle power by 15% ($p<0.05$). Control group's RE remained unchanged ($p>0.05$).	Plyometric training can improve the RE in well-trained runners without changing their VO_{2max}.
Mikkola et al.	25 trained endurance	Experimental group	Maximal speed of	The concurrent

(2007)	runners randomly divided into an experimental (n=13) and control (n=12) group. The cohort's age ranged from16-18 years.	concurrently plyometric and endurance run trained for 8 weeks. The control group completed their endurance running.	maximal anaerobic running test and 30m dash improved by 3.0±2.0% and 1.1±1.3% respectively ($p<0.05$). However VO_{2max} and RE did change for both groups ($p>0.05$).	explosive strength and endurance running improved anaerobic and selected neuromuscular characteristics without decreases in $V0_{2max}$ and RE.

Table 3. Concurrent core strengthening and endurance running

Study	Participants	Training type	Outcome measure	Findings
Robert et al. (2004)	18 runners were randomly divided into an experimental (n=8) and control (n=10) group. The cohort's mean age, body mass and VO_{2max} were 15.5±1.4 yrs., 62.5±4.7kg and 55.3±5.7m/kg/min^{-1}	The experiment group completed concurrent Swiss ball core stability and running programme. The control completed normal training. The experimental group completed 2 additional sessions per week for 6 weeks.	VO_{2max} and RE remained unchanged ($p>0.05$), however core stability improved ($p<0.05$).	Swiss ball training may positively affect core stability without concomitant improvements VO_{2max} and RE among trained runners.
Sato & Mokha, 2009	20 runners were randomly divided into an experimental (n=12) and control (n=8) group. The cohort's mean age, body mass and height were 36.9±9.4 yrs., 70.1±15.3kg and 1.68±0.9m respectively.	The experimental group completed concurrent core strengthening and running, while the control completed running for 6 weeks.	The experimental group's core strength and 5000m running performance improved ($p<0.05$) in comparison to the control ($p>0.05$).	The experimental group increased their core strength which was attributed to their improved 5000m time trail performance

Table 4. Impact of concurrent strength and endurance training to prevent and rehabilitate running musculoskeletal injuries

Study	Participants	Training type	Outcome measure	Findings
Snyder et al. (2009)	15 healthy female runner complete lower limb strengthening and endurance running. The cohort's mean age, body mass and height were 21.9±1.2 yrs., 63.9±6.4kg and 1.54±0.05m respectively.	The runners completed 3 lower limb strength training sessions per week for 6 weeks in addition to their running.	Hip abduction, external rotation strength improved 13% and 23% ($p<0.01$), while knee abduction moment decreased by 10% ($p<0.05$).	The hip abductors and external rotators were strengthened, leading to an alteration of lower extremity joint loading which may reduce injury risk.
Willy & Davis, (2011)	20 female runners with excessive hip adduction were randomly assigned to a control (n=10) or experimental (n=10) group. Experimental and control group's mean age and BMI were 22.7±3.5 yrs., 22.3±2.3kg.m^{-2} vs. 21.2±2.2 yrs., 22.2±2.9kg.m^{-2} respectively.	The experimental group completed 3 lower limb strength training sessions/week for 6 weeks in addition their running. The control completed running.	Hip, external rotator strength and contra-lateral pelvic drop improved ($p<0.05$) among the experimental group in comparison to the control ($p>0.05$).	Lower limb strength training increases lower limb strength without influence running biomechanics

Discussion

The discussion of results will be presented in the following sections; (i) concurrent strength and endurance training in relation to RE, VO_{2max}, LT (ii) concurrent core strengthening and endurance running, and (iii) impact of concurrent strength and endurance training to prevent and rehabilitate running musculoskeletal injuries.

Concurrent strength and endurance training in relation to RE, VO_{2max}, LT

The efficacy of concurrent strength and endurance training is measured by the positive changes in RE, VO_{2max} and LT.

Running economy

Running economy is described as the amount of energy required to run at a given sub-maximal speed, which are influenced by the individual's body mass and distinctive running style. Runners with lighter body mass expend less energy to run a given distance at a given speed, resulting in less oxygen consumption compared to heavier runners (Saunders et al., 2004). The significance of RE, becomes evident when a cohort of elite runners' with similar VO_{2max} who are competing, resulting in the runner with most efficient RE winning (Noakes, 2005).

Poor running biomechanics such as excessive foot pronation, leg length discrepancy, lordosis, circumductive gait and short running strides increase RE (Noakes, 2005). McArdle et al. (2005) reported that efficient running biomechanics improves RE (Jung, 2003).

Strength training has shown to improve RE through the following mechanisms:

i. Core and upper body strength training delay the onset of muscle fatigue, which enables the runner to maintain an efficient running biomechanics, minimizing RE (Jung, 2003).
ii. Strength training increases the force generated by the muscles, allowing the runner to complete a given distance quicker at the same stride frequency (RE). This improved RE is associated to the muscles ability to efficiently store and recover elastic energy during contractions. Greater force generated per stride produces an optimal stride length, allowing the runner to complete a given distance quicker at the same stride frequency (Jung, 2003).

iii. Strength training increases the dynamic stability of the lower limb joints, and decreases the amount of energy expended to brake on heel touch. This conserved elastic braking energy is stored and added to the subsequent muscle contraction to generate a stronger force during heel off (Saunders et al., 2004).

iv. Chtara et al. (2005) claim that strength training enhances the neuromuscular interaction, as it elicits more efficient neural activation of muscle fibers. The enhanced neuromuscular efficiency is derived through; quicker nerve firing, more motor units having been recruited, and enhanced synchronization of motor units function, towards a common goal.

Maximal oxygen consumption

Maximal oxygen consumption also known as aerobic power is the highest rate at which oxygen can be consumed and utilized (Jung, 2003). Improvements in VO_{2max} can be derived through either of the following training techniques:

- long distance run paced at a moderate to high intensity of 65-85% of VO_{2max}
- repeated short distance running at a higher intensity of VO_{2max} (80-100% of VO_{2max})

Balabaninis et al. (2003) documented that concurrent strength and endurance training does not influence VO_{2max} as they produce different muscular adaptations (Table 5).

Table 5. Aerobic and anaerobic training adaptations induced by endurance running and strength training respectively

Aerobic	Anaerobic
i. increased capillary density (McArdle et al., 2005), ii. increased mitochondrial size and number (Jung, 2003), iii. increased oxidative enzymes (McArdle et al., 2005), iv. activation of type 1 muscle fibers, facilitating its hypertrophy (McArdle et al., 2005), v. increased blood volume (McArdle et al., 2005)	i. decreases capillary density (Jung, 2003) ii. reduction in mitochondrial density (McArdle et al., 2005) iii. decreases metabolic activity and intramuscular substrate stores (McArdle et al., 2005) iv. predominantly activates type 2 muscle fibers, producing type 2 muscle fiber hypertrophy (McArdle et al., 2005).

Exercise scientists argue that resistance training provides an aerobic stimulus not greater than 50% of VO_{2max}, therefore cannot increase, the aerobic capacity (Jung, 2003).

Empirical investigations examining the effectiveness of concurrent strength and endurance training has concluded the following:

i. Endurance runners will not improve their VO_{2max} with resistance training, as the aerobic stimulus provided is below the required threshold of 60% of VO_{2max}.
ii. The myth that concurrent resistance strength and endurance training will decrease the VO_{2max} is false. The addition of resistance training to an endurance running programme may be of value other than improving VO_{2max} (Jung, 2003).

Lactate threshold

Lactate threshold denotes the point at which blood lactate accrues above resting values during escalated exercise intensity. Jung (2003) reported that LT is a significant predictor of endurance running performance. An endurance runner who possesses a high LT is able to run at a higher percentage of their VO_{2max} before their lactate production exceeds removal rate (Jung, 2003). Studies conducted after 2003 have yielded similar findings to Jung (2003) consensus suggesting that runners would not improve their LT as a result of concomitant strength and endurance training. Evidence demonstrates that strength training does not impede LT, indicating that endurance runners could perform concurrent strength and endurance training without a decrease in LT.

Concurrent core strengthening and endurance running

There are contradictory findings regarding the effects of concurrent core strengthening and endurance running. Sato and Makho (2009) reported that core strengthening enhanced running performance, while Robert et al. (2003) reported that core strengthening does not impact runners' VO_{2max} and RE. Further research is required to validate these findings.

Impact of concurrent strength training and endurance training to prevent and rehabilitate running musculoskeletal injuries

Synonymous with the beneficial physiological adaptations of endurance running is the subsequent maladies that frequent accompany this sport, the most common type being the onset of running musculoskeletal injuries. Predisposing factors contributing to musculoskeletal running injuries include poor training habits, inadequate rehabilitation of previous injuries, high weekly mileage and incorrect shoes and muscle imbalances (Lun et al., 2004, Puckree et al., 2007). Literature has identified the knee as the anatomical site most vulnerable to running musculoskeletal injury followed by the ankle, hip and tibia and fibula (Puckree et al. 2007, Ellapen et al., 2013). Much literature has been published that advocates the prescription of strengthening exercises for both preventing and rehabilitating running injuries (Prentice, 2004). Synder et al. (2009) and Wills and Davies (2011) have prescribed lower limb strengthening exercises to hip adductors and abductors in an attempt to reduce hip injuries. Empirical investigations reported that core strengthening and endurance running improved core stability, endurance running performance, and decreased risk of injury without reducing runners' VO_{2max} and RE (Robert et al., 2004, Sato & Mokka, 2009). Physical therapists, physiotherapists and biokineticists suggest that endurance runners should comply with concurrent strength and endurance training in an attempt to combat the ill effects of musculoskeletal injuries. It is recommended that future research of a prospective nature be conducted to determine the valuable of concurrent strength and endurance training as a preventative measure to musculoskeletal running injuries.

Conclusion

Evidence supports the postulation that concurrent strength and endurance training does positively influence runners' RE. It appears that concurrent traditional resistance training is more beneficial to endurance running than plyometrics. Furthermore, core stability training does increase core strength but its effect on endurance running performance is inconclusive. The application of concurrent strength training as a preventive measure to reduce the incidence of musculoskeletal injuries has been successful. The following limitations were identified; (i) small sample among the studies, (ii) short duration of the intervention. It is recommended that future prospective randomized controlled studies use large samples and longer interventions, and that other variables such as completion times of 10km, 21.1km and 42.2km be used to determine the success of concomitant strength training and endurance running.

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Linkage between manuscripts:

The previous publication indicated that concurrent strength training and endurance running improves the running economy of endurance runners, without impacting on their VO_{2max} and lactate threshold. There are many strength and conditioning programs that are used by coaches.

According to Davies G (2015) plyometrics may be incorporated as an important component of an exercise program that can produce all the aforementioned outcomes. As tremendous forces are imposed on the upper and lower extremities during sports and athletics, there is a big demand for power during the performance phase. Of the numerous types of available exercises, plyometrics assist in the development of power, a foundation from which the athlete can refine the skills of their sport.

However in an African context strength and conditioning practices are often overlooked. The subsequent manuscript draft chapter reports on the results of a survey done to specifically determine the knowledge, attitudes and practices with respect to plyometric training among coaches in high schools in the province of Harare, in Zimbabwe. This results chapter is an extension of the general introduction, and methodology of the project, as expounded in the introductory chapter (1).

CHAPTER THREE: SECOND MANUSCRIPT

Knowledge, Attitudes and Practices of Plyometrics among High School Sports Coaches in Harare Province, Zimbabwe

I Munekani and HJ van Heerden

3.1 Introduction

This chapter details the results obtained from a survey that was carried out to examine high school sports coaches' knowledge, attitudes and practices of plyometrics in Harare Province, Zimbabwe. The results are discussed section by section and graphs are provided for ease of reference to the descriptive statistics. The results are shown comparing the distribution of age categories, gender, years of coaching (experience) and the sports coached. The results also show the education level of the coaches and their knowledge of plyometric strength training exercise. The high school coaches' overall scores of the survey, as well as each section are explored and possible reasons for these scores are discussed. The significance of the coaches' knowledge in each section is discussed, compared to previous studies of the similar nature and the implications of the results are explored.

3.2 Demographics

Age

The age of the high school coaches that participated in the survey ranged from 18- 59 years. There were significantly more coaches (46%; $p \leq 0.0001$) in the 30 - 39 years age range.

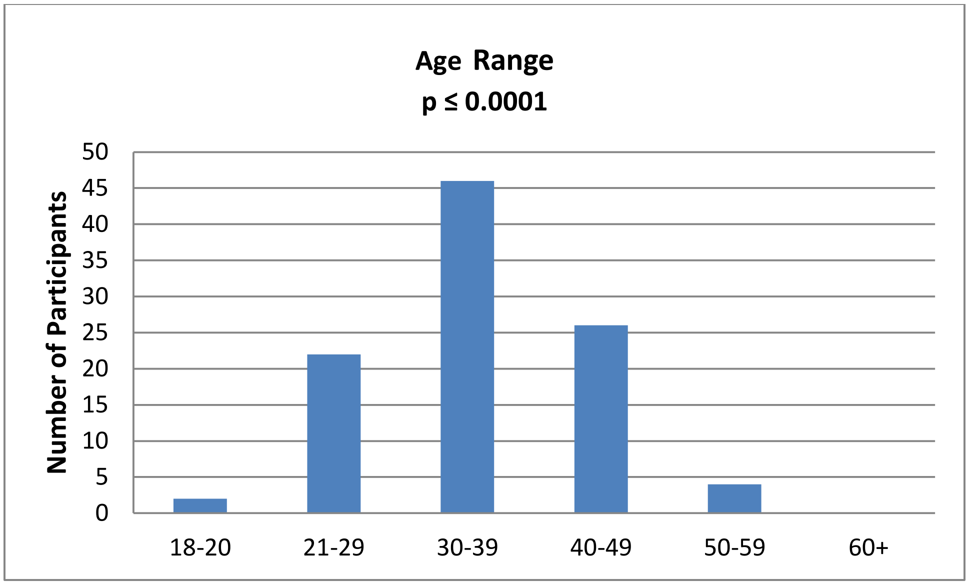

Figure 3. 1: The distribution of age categories among high school sport coaches (n=100).

Table 3. 1: The distribution of age categories amonghigh school sport coaches (n=100).

Age Range	Frequency (n=100)	p value
18 - 20	2	≤0.0001
21 - 29	22	
30 - 39	46	
40 - 49	26	
50 - 59	4	
60 and above	0	

Gender

The majority of the sport coaches were males. Of the one hundred coaches, 22 were females and 78 were males ($p \leq 0.0001$) in the 45 schools that participated in the survey.

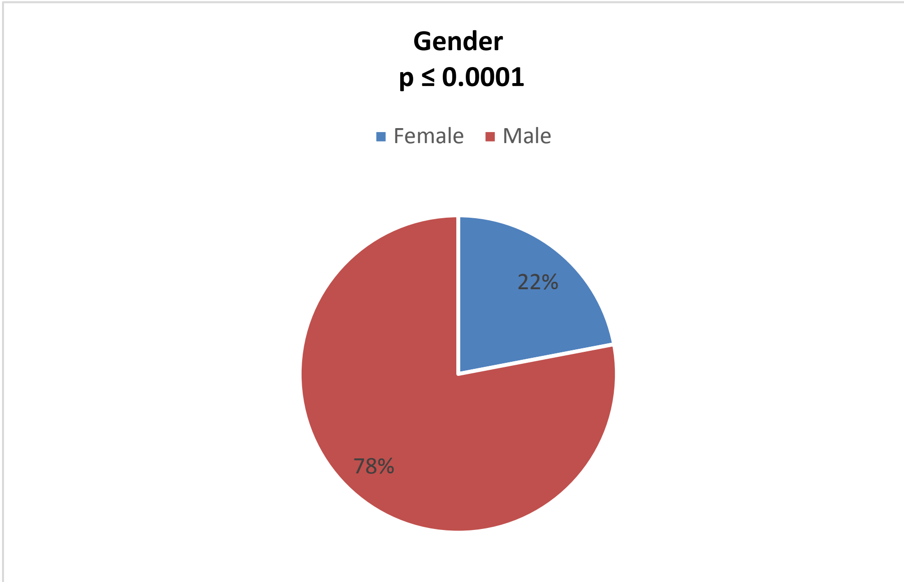

Figure 3. 2: The distribution of gender among high school sport coaches (n=100).

Table 3. 2: The distribution of gender among high school sport coaches (n=100).

Gender	Frequency (n=100)	p value
Female	22	≤0.0001
Male	78	

Years of Experience

The years of coaching experience ranged from one to twenty years of coaching. There were significantly more coaches with 5 – 15 years of experience ($p \leq 0.0001$). From the participants there was no one who indicated that they had more than 20+ years of coaching experience.

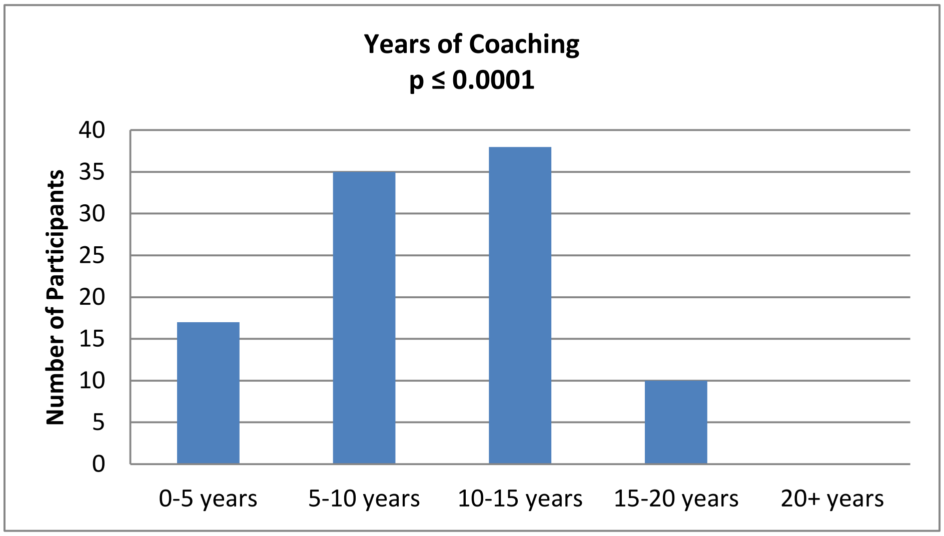

Figure 3.3: The distribution of the number of years of coaching experience among high school sport coaches (n=100).

Table 3.3: The distribution of the number of years of coaching experience among High school sport coaches (n=100).

Years of coaching	Frequency (n=100)	p value
0-5 years	17	$p \leq 0.0001$
5-10 years	35	
10-15 years	38	
15 -20 years	10	
20 years and above	0	

Utilization of Plyometric Training

The high school coaches indicated that the small but insignificant ($p>0.05$) majority (56%) of the coaches have their athletes perform plyometric strength training exercises as part of a training plan.

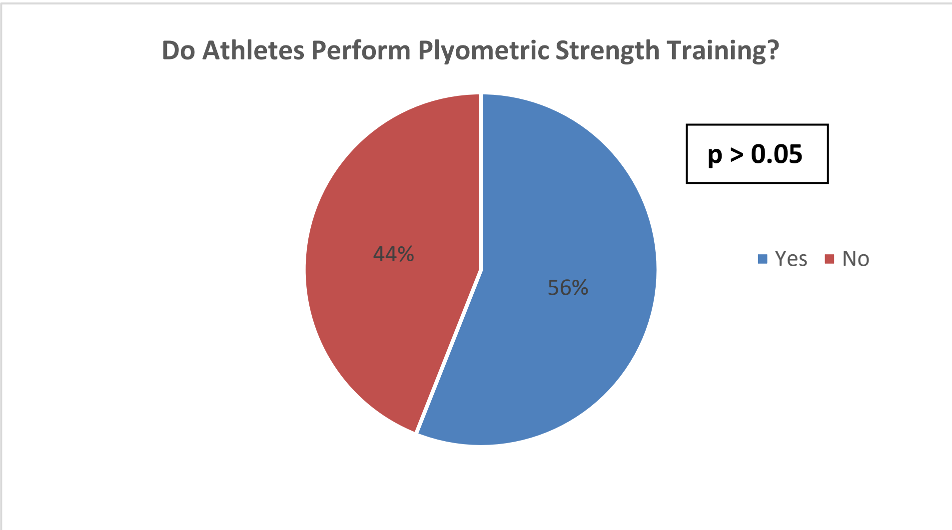

Figure 3. 4: The distribution of the number of coaches who have their athletes perform plyometric strength training exercise among high school sport coaches (n=100).

Table 3. 4: The distribution of the number of coaches who have their athletes perform plyometric strength training exercise among High school sport coaches (n=100).

Do Athletes Perform Plyometric Strength Training	Frequency (n=100)	p value
Yes	56	p>0.05
No	44	

Gender Classification of Sports Coached

From the 45 schools that participated there are significantly more male sports (55%; $p \leq 0.01$) being coached in Harare. The result is also indicated with the higher number of male coaches that participated in the survey. A few male coaches indicated that they coached female sports.

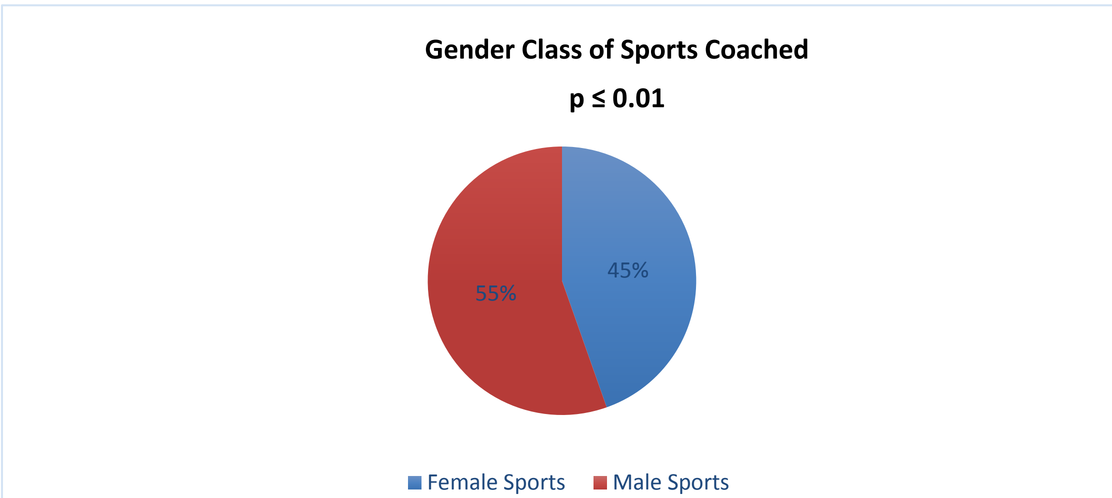

Figure 3. 5: The distribution of the number of sports coached according to gender among high school sport coaches (n=100).

Table 3. 5: The distribution of the number of sports coached according to gender among high school sport coaches (n=100).

Gender	**Frequency (n=100)**	**p value**
Female Sports	55	$p \leq 0.01$
Male Sports	45	

Former Participation in Competitive Sport

Almost all the coaches (95%; $p \leq 0.0001$) in the high schools that took part in the survey, highlighted that they have participated in competitive sports themselves. However the need for coaches to improve their knowledge of sports coaching and training, remains essential. The assumption that because you were good at sports, does not ensure that one can coach without furthering your qualifications and experiences.

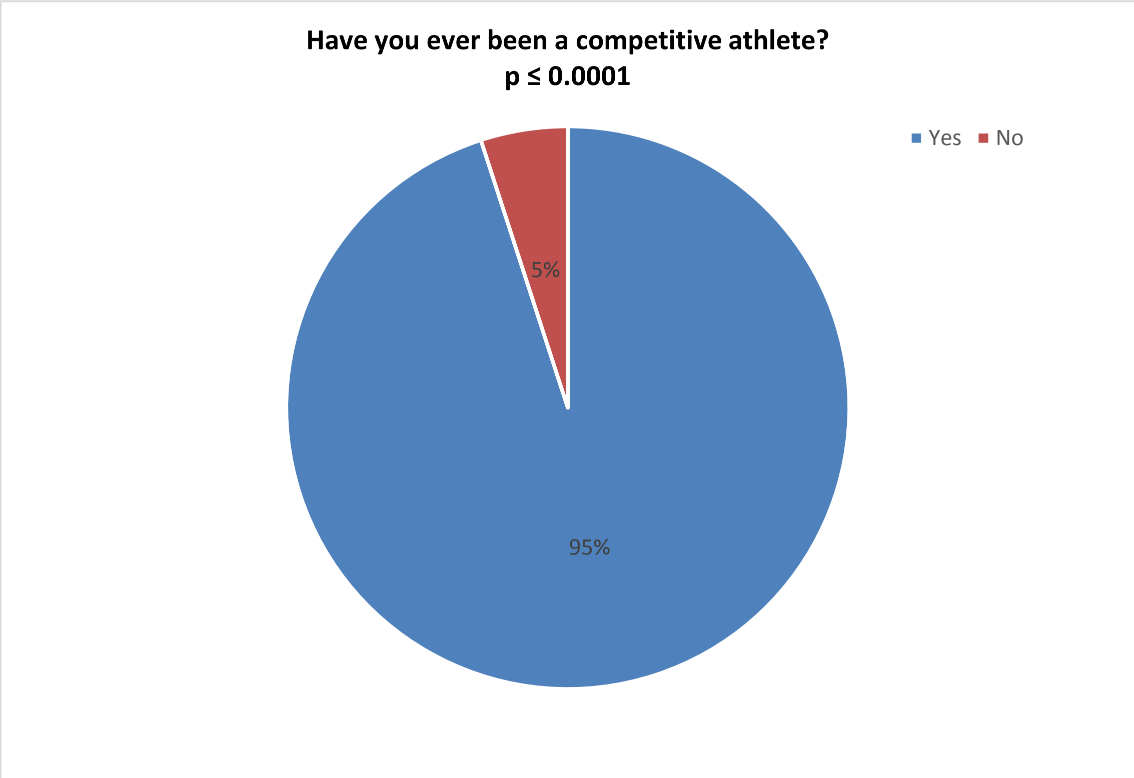

Figure 3. 6: The distribution of the number of coaches who have been competitive among high school sport coaches (n=100).

Table 3. 6: The distribution of the number of coaches who have been competitive among high school sport coaches (n=100).

Have you ever been a competitive athlete?	Frequency (n=100)	p value
Yes	95	$p \leq 0.0001$
No	5	

Former Participation in Plyometrics

Of the coaches who responded positively to being competitive athletes themselves, indicated that the significant majority (79%; p≤0.0001) of them had never performed plyometric strength training exercise. Coaches need to improve their sporting experiences in order to expose the athletes to a variety of training methods that would improve their athletic performances.

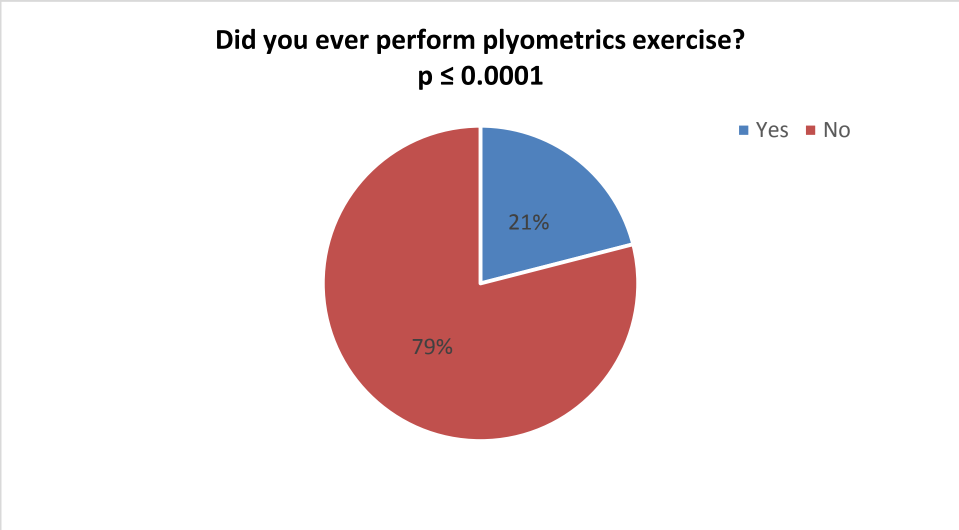

Figure 3. 7: The distribution of the number of coaches who performed plyometric strength training exercises among high school sport coaches (n=100).

Table 3. 7: The distribution of the number of high school athletic coaches who had performed plyometric strength training exercises (n=100).

Previous performance of plyometric exercise	**Frequency (n=100)**	**p value**
Yes	21	p≤0.0001
No	79	

Formal Plyometrics Education

As to be expected, much as the majority of the coaches had not performed plyometric strength training exercise as athletes themselves, the significant majority (94%; $p \leq 0.0001$) of them did not have any formal training or education in plyometric strength training.

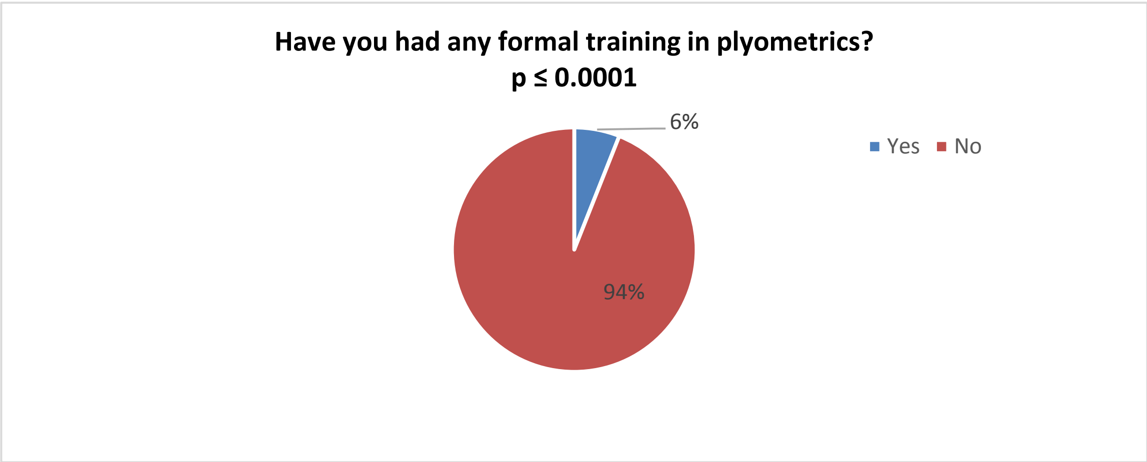

Figure 3. 8 The distribution of the number of coaches who had formal training on plyometric strength training exercises among high school sport coaches (n=100).

Table 3. 8: The distribution of the number of coaches who had formal training on plyometric strength training exercises among high school sport coaches (n=100).

Have you had any formal training in plyometric exercise?	Frequency (n=100)	p value
Yes	6	$p \leq 0.0001$
No	94	

Without a formal training in plyometric strength training the coaches had limited knowledge on plyometric exercises. This was borne out in their scores in the plyometrics knowledge section, as reported subsequently.

Coaching and Related Education

All the coaches had some form of education except for one coach who indicated having none of the qualifications on the research questionnaire. The significant majority of coaches (87%; p≤0.0001) had either a Degree in Physical Education (42%) and/or a Teaching Diploma (45%).

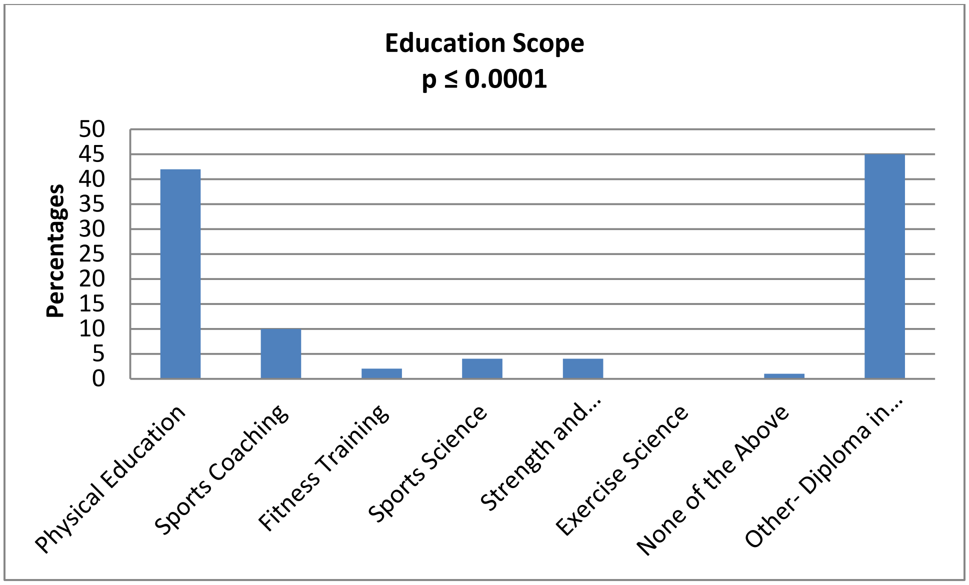

Figure 3. 9: The distribution of the level of education amongst high school sport coaches (n=100).

Table 3. 9: The distribution of the coaches' level of education among high school sport coaches (n=100).

Education Scope	Frequency (n=100)	p value
Physical Education	42	p≤0.0001
Sports Coaching	10	
Fitness Training	2	
Sports Science	4	
Strength and Conditioning	4	
Exercise Science	0	
None of the Above	1	
Diploma in Education	45	

3.3 Coaches' Knowledge of Plyometric

Following the survey of the coaches' knowledge of Plyometric Strength Training Exercise, it was evident that the coaches had poor (low) knowledge of plyometric training. The mean score for the coaches with regards to their responses to a 20 item questionnaire on knowledge of plyometric training, was 7.09 out of 20 (± SD 4.0), with an average percentage score of 35.5% out of 100, which was below the expected 50% for a normal distribution, indicating a poor level of knowledge. The reason for this finding may be due to the fact that most coaches had not been formally trained in plyometrics.

The absence of formal training and a lack of knowledge in plyometrics among coaches, in general, is reflected upon by Shehab et al. (2006) who suggest that coaches typically use personal experience as well as scientific research when recommending plyometric exercises to their athletes. However this is unsatisfactory, because if the coaches were using specific knowledge on plyometric training, their athletes will have programs that are implemented in a safe and correct manner. Therefore educating coaches regarding plyometric training is essential.

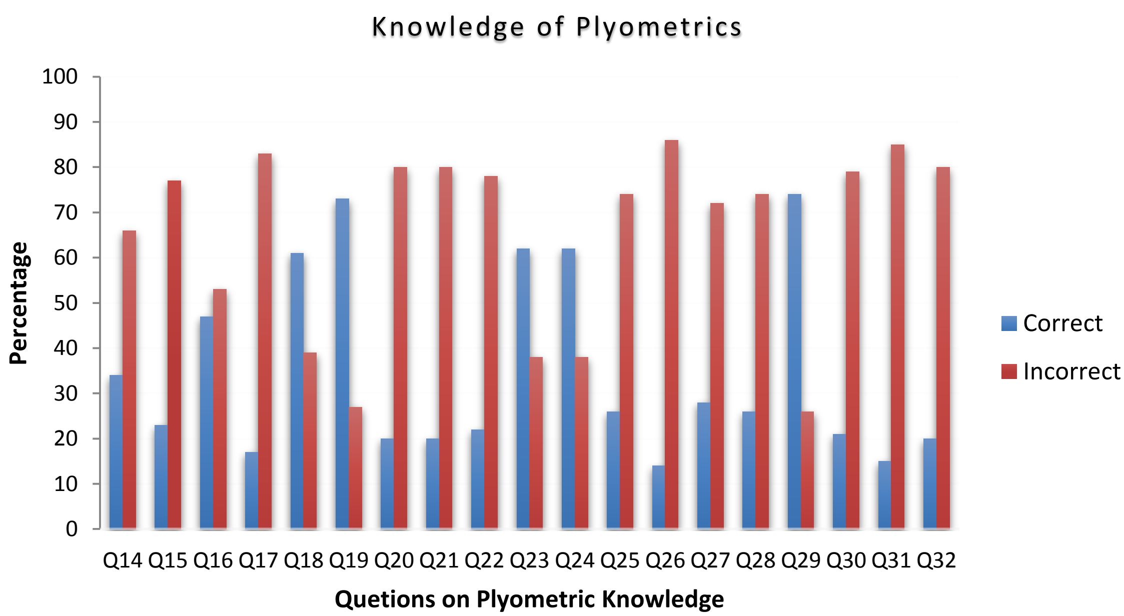

Figure 3. 10: The distribution of responses given by coaches on the knowledge section (n=100).

Table 3. 10: The distribution of responses by high school coaches on knowledge of plyometrics n=100).

PLYOMETRICS KNOWLEDGE	Correct %	Incorrect %	p value
1. Primary goals of plyometric exercise	34	66	≤ 0.001
2. Manner / speed of performing plyometrics	23	77	≤ 0.0001
3. Physiological effects of plyometrics	47	53	> 0.05
4. Advantages of plyometric exercise	17	83	≤ 0.0001
5. Components of a plyometric training program	61*	39	≤ 0.05
6. Low intensity exercises and foot contacts	73*	27	≤ 0.0001
7. Rest ratio when performing plyometrics	20	80	≤ 0.0001
8. Factors in plyometrics directly related to increase in power output	20	80	≤ 0.0001
9. Plyometrics and injury-specific prevention in females	22	78	≤ 0.0001
10. Vertical jump landing differences between males and females	62*	38	≤ 0.05
11. Risk of ACL injuries in females compared to males	62*	38	≤ 0.05
12. Plyometric exercise as a component of other strength programs	26	74	≤ 0.0001
13. Rapid switches from eccentric to concentric contraction	14	86	≤ 0.0001
14. Proprioceptive ability emphasis in plyometric exercise	28	72	≤ 0.0001
15. Order of progression in plyometric training	26	74	≤ 0.0001
16. Dynamic planes of motion in plyometrics	74*	26	≤ 0.0001
17. Equal hip muscle activation ratios and control of other movements	21	79	≤ 0.0001
18. Signs of contra-indication for progression	15	85	≤ 0.0001
19. Signs of excessive intensity in plyometrics training	20	80	≤ 0.0001
20. Preference to use plyometric exercises more often in training	**Yes**	**No**	> 0.05
	44	56	

The starred figures in the above table indicate responses where the majority of responses were correct.

As reflected in table 3.10 above, there were significantly ($p \leq 0.05$) more incorrect responses to the questionnaire (15 from 20 questions; 75%) than correct ones. This is also reflected in the overall score for the questionnaire which was below the expected normal distribution average score of 50%. Only in 5 of the 20 questions (25%) on the knowledge section, did more coaches have the correct response or answer. These were questions related to the components of a plyometric training program, foot contacts and intensity, vertical jump landing differences between males and females, the risk of ACL injuries in females compared to males, and dynamic planes of motion in plyometrics. These questions did not require the respondents to be knowledgeable in plyometric training but, more so, they required logical reasoning.

The minority of the participants (44%) in item 20, indicated that they would use plyometric exercises in their training program more often. The participants' low knowledge of plyometric training exercises evidently would have influenced such a hesitant low response to take up the practice of plyometrics.

3.3.1 Plyometric knowledge between coaches based on gender

There was a slight difference in plyometric knowledge between coaches of different gender at high school level. Both males (37.7%) and females (25.6%) average percentage score on plyometric knowledge were below the expected score (50%). The scores were both poor but the score for males was better than that for females.

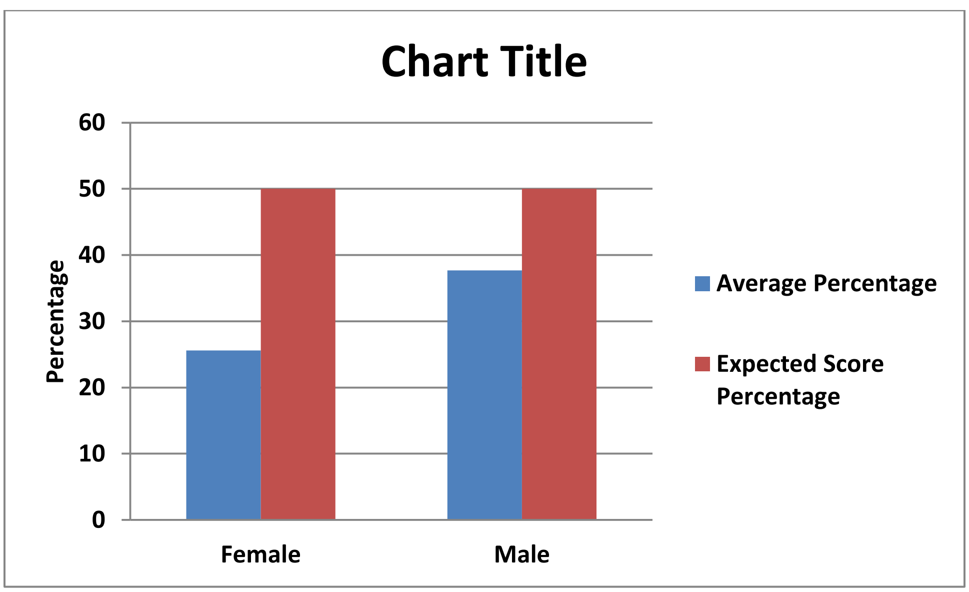

Figure 3. 11 Distribution of the difference in plyometric knowledge percentage score between coaches of different gender at high school level (n=100).

In considering the total correct responses to the 20 point questionnaire (table 3.11) below, male **coaches** scored significantly better (n=580; p ≤ 0.0001) than female coaches.

Table 3. 11 Distribution of the difference in plyometric knowledge responses between coaches of different gender at high school level (n=100).

Gender	Correct Responses	Incorrect Responses	p value
Male (N=78)	580	980	≤ 0.0001
Female (N=22)	129	311	
Total	**709**	**1291**	**2000***

**Based on 100 respondents potentially answering correctly to all 20 questions*

3.3.2 Plyometric knowledge between coaches based on coaching experience

The range of experience among the coaches is reflected in figure 3.12 below.

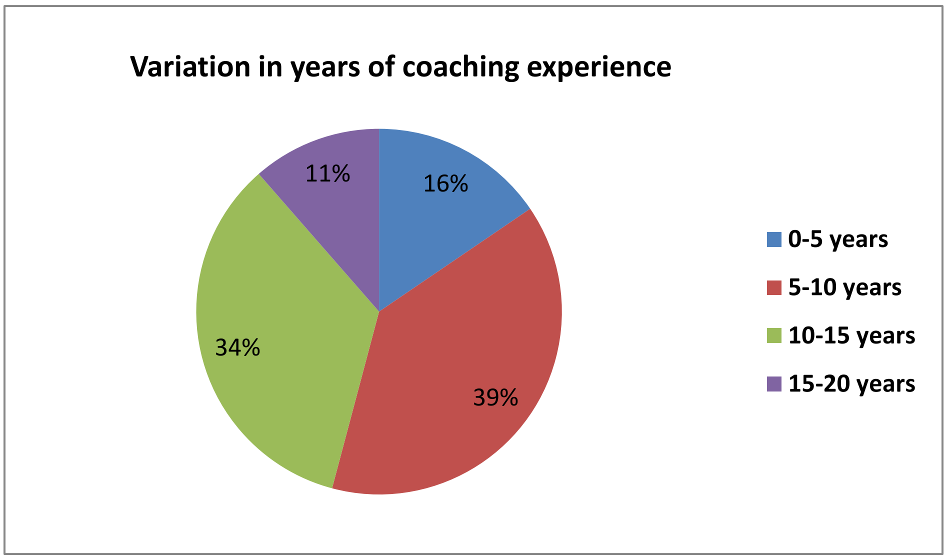

Figure 3. 12: Distribution of the difference in plyometric knowledge between coaches based on their years of coaching at high school level (n=100).

The majority of coaches were in the categories 5-10 years (39%) and 15-20 years (34%), while there were fewer younger coaches with 5 years or less experience (16%) and older coaches with 15-20 years of experience (11%).

There is a difference in plyometric knowledge between coaches based on their years of coaching experience (table 3.12). The score for 0-5 years of coaching was 28.5% which was slightly above that of

15-20 years of coaching which was 21.1%. Categories 5-10 years and 10-15 years of coaching performed well. They were above the expected score (50%). Coaches with 5-10 years of coaching experience scored the best (71.2%) which was above that of 10-15 years of coaching at 63.4%. In considering the total correct responses to the 20 point questionnaire, coaches in the 5-10 (n=270) and 10-15 (n=310) years of experience categories, scored significantly better ($p \leq 0.0001$) than those in the other experience categories.

Table 3. 12: Distribution of the difference in plyometric knowledge between coaches based on their years of coaching at high school level (n=100).

Years of Coaching	Average % Score	Correct Responses	Incorrect Responses	p value
0-5 years	28.5	76	264	$p \leq 0.0001$
5-10 years	71.2	270	430	
10-15 years	63.4	313	447	
15-20 years	21.1	50	150	
Total		**709**	**1291**	**2000***

**Based on 100 respondents potentially answering correctly to all 20 questions*

3.3.3 Plyometric knowledge between coaches based on qualifications and educational training

There was a definite difference in plyometrics knowledge based on qualifications and educational training of the coaches, as reflected in figure 3.13.

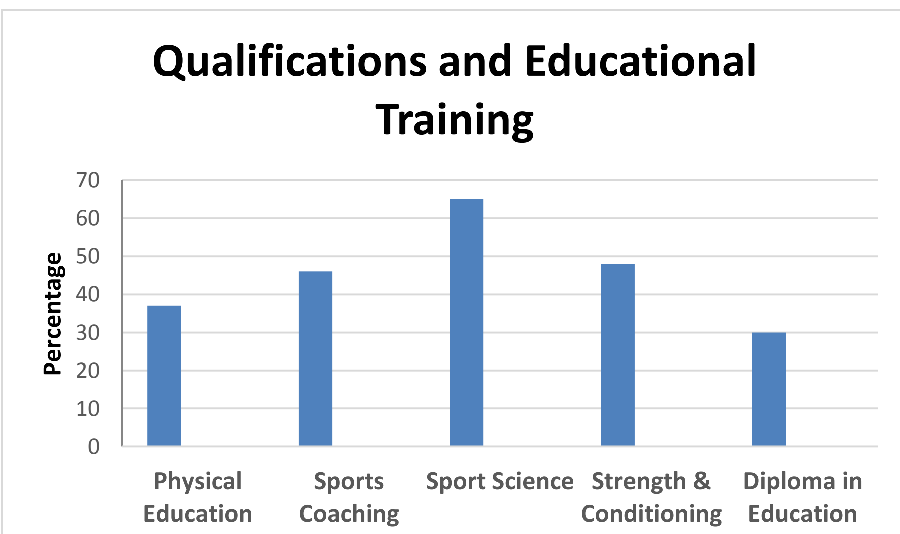

Figure 3. 13: Distribution of the difference in plyometric knowledge score percentage between coaches based on their qualifications and educational training at high school level (n=99).

The highest average plyometrics knowledge score (65%) was shown in coaches with a Sport Science qualification. This was followed by those with strength and conditioning training (47.5%), training in sports coaching (46.4%), physical education (37%) and a diploma education (30.2%) – although all of these coaches scored below the expected 50% pass rate. In considering the total correct responses to the 20 point questionnaire (table 3.13), coaches with a qualification in sport science scored a significantly higher proportion of correct responses ($p \leq 0.0001$) than those with other or related qualifications and training.

Table 3. 13: Distribution of the difference in plyometric knowledge between coaches based on their qualifications and educational training at high school level (n=99).

Educational Training	Average % Score	Correct Responses	Incorrect Responses	p value
Physical Education	37.0	296	504	
Sports Coaching	46.4	65	75	
Sports Science	65.0	39	21	≤ 0.0001
Strength & Conditioning	47.5	2	38	
Diploma in Education	30.2	284	656	
Total		**686**	**1294**	**1980***

**Based on 99 respondents potentially answering correctly to all 20 questions*

3.4. Conclusion

The aim of the study was to examine the knowledge, attitudes and practices of plyometrics among high school sports coaches in Harare Province, Zimbabwe.The results of the study indicated that the high school coaches in the Harare Province of Zimbabwe, are typically between 30 to 39 yrs of age, with between 5 and 15 years of coaching experience and are mostly male. Slightly more than half of the coaches let their athletes perform plyometrics. While almost all of the coaches have previously participated competitively themselves, very few have previously done plyometrics themselves and very few have any formal training in plyometrics. With the exception of coaches with training in sport science, who scored an average of 65% for a 20 item knowledge test on plyometrics, generally the coaches have very poor knowledge with regards to plyometric strength training exercise. Although male coaches knowledge was better than that of females and those with 5-15 years of experience had better knowledge than those with more than 15 years of experience, overall the coaches only managed to scoring an average of 35% for the same a 20 item knowledge test on plyometrics, and accordingly there is a resistance to using plyometrics more often in the training of their athletes.

CHAPTER FOUR: SYNTHESIS

4. Contextualization

4.1 Introduction

This chapter contextualizes the current knowledge of high school coaches in Harare Province. One of the primary training goals of plyometric exercise is to increase maximal power output and jumping ability, which when used in a safe and correct manner has been shown to produce positive results such as increased jump height, development of muscle power and increase muscular endurance. According to Markovic (2007) plyometric exercise has been shown to potentially decrease lower extremity injuries when implemented in a safe and effective manner. This synthesis is presents the evaluation of the research, discussing the strengths and limitations as well as recommendations for practice, policy and research.

4.2 Evaluation of the research

4.2.1 Strengths

The research was conducted within the Harare province and thus was a good indication of the level of the high school coaches' knowledge, attitudes and practices of plyometric strength training. The sample was obtained from a large population with the response rate of 67%. 150 questionnaires were distributed and 100 questionnaires were returned.

The research process was thorough and effective as follow up appointments were made to collect surveys from participants. The response rate improved due to the personal contact made between the researcher and the respondents. Lastly due to the fact that an appointment was made to follow up, the researcher did not bother the respondents at inconvenient times (De Vos et al, 2002).

There are many high school students and athletes. The quality of strength and conditioning they receive is crucial to their long-term athlete development therefore, it is crucialthat we asSport Science researchers understand the level of knowledge, attitudes and practicesof plyometricsamong high school sports coaches.

4.2.2 Limitations

The nature of the survey data that was obtained was self-reported and so the results obtained may have been subject to recall bias on the part of the high school coaches. Questionnaires were sent to both public and private schools, however majority of the feedback was from private schools. The low response from public schools was also influenced by the fact that most coaches were not in their schools as they were involved in the National Athletics Competitions for High Schools that took place in the month the researcher was doing data collection. The relatively low number of female coaches in the sample may be considered as a limitation but it is argued that, in the experience of the researcher, it reflects the situation in practice.

4.3 Implications for practice

The coaches' application of their knowledge needed to be established to understand whether the coaches are applying plyometric strength training in their programs. It is evident that the coaches are not applying plyometric strength training exercises, and the coaches need to be educated regarding plyometrics.

4.4 Recommendations for policy

Due to the finding that the coaches' knowledge of plyometric strength training was poor or rather mostly incorrect, it is important to include plyometric strength training in coaching courses. Sharing the results of the current study with the coaches that participated as well as with the Department of Education and the Coaches Associations, is necessary in order to advocate for changes in policy/protocol, with regards to coaching Education.

4.5 Recommendations for experiential training

There is a need for Work Integrated Learning (WIL) for all coaches and physical education teachers in private and government schools with respect to strength and conditioning and plyometrics, in particular. The researcher recommends the application of the outcomes from a study by Desai and Seaholme (2018), that is to incorporate a supervised relationship-based educational experience (internship) for strength and conditioning to be applied to a range of contexts for sports coaches and students in health and wellness, along the following practical lines:

Relationship:

- Foster a relationship with coaches
- Passive participation of supervisor during training sessions and
- Provide individualized feedback to coaches

Ownership:

- Lead the internship
- Mould their internship experience and
- Perform typical tasks of a strength and conditioning

Professional Satisfaction:

- Allocating suitable time for supervision and feedback
- Offering systematic and formalized feedback
- Including coaches in the decision-making process
- Communicating standards of success and benchmarking coaches level of achievement
- Clarifying internship objectives

- Providing opportunities for coaches to self-reflect on their strength and conditioning performance

Professional specific skills:

- Coaches need to understand the behaviors of an effective strength and conditioning professional
- Those behaviors and skills are taught by supervisor either by modelling or through facilitation
- Create opportunities for coaches take on responsibilities that are similar to that of an strength and conditioning professional
- Creating opportunities for coaches to be reflective, data driven, intentional and purposeful as an strength and conditioning professional

4.6 Recommendations for the future research

The following topics for further research would be prudent:

- To focus on high school coaches that currently do implement plyometric exercises in their programs to get a clearer assessment of their knowledge of plyometric training and how they implement them at their high school setting.

- There is need for a study of a similar nature to look at the KNAP of strength and conditioning among coaches in the primary school setting.

- A project that examines if implementing the four elements of the Desai and Seaholme (2018) model in a range of WIL contexts yields positive outcomes for coaches and physical education teachers.

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APPENDIX A

UNIVERSITY OF KWAZULU-NATAL

SCHOOL OF HEALTH SCIENCES

DISCIPLINE OF SPORT SCIENCE

Information sheet for participants

KNOWLEDGE, ATTITUDES AND PRACTICES OF PLYOMETRICS AMONG HIGH SCHOOL COACHES IN HARARE PROVINCE ZIMBABWE.

Thank you for showing an interest in this survey. Please read this information sheet carefully.

Aim of the study?

To examine high school coaches' knowledge, attitudes and practices of plyometrics.

Subjects

Subjects in this study will be high school coaches in the Harare Province.

Participants are required to

Participants are expected to complete the given questionnaire. Participants' identity will be maintained confidential throughout the study. All raw data will be retained in secure storage for five years, after which it will be destroyed.

Remuneration

No remuneration will be awarded for taking part in the survey.

Withdrawal from the study

You may withdraw from participation in the study at any time and without any disadvantage to yourself of any kind.

Enquiries

If you have any questions about the survey, either now or in the future, please feel free to contact.

Prof J van Heerden (Supervisor) Email : vanheerdenj@ukzn.ac.za

Miss I Munekani (Student researcher) Cell: 071 844 3822

Email: imunekani@yahoo.com

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Website: http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

APPENDIX B

UNIVERSITY OF KWAZULU-NATAL

SCHOOL OF HEALTH SCIENCES

DISCIPLINE OF SPORT SCIENCE

Informed Consent Form

KNOWLEDGE, ATTITUDES AND PRACTICES OF PLYOMETRICS AMONG HIGH SCHOOL COACHES IN HARARE PROVINCE ZIMBABWE.

I have read the Information Sheet concerning this survey and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage. I know that:

1. My involvement in the survey is entirely voluntary;
2. I am aware that there is no remuneration fee for taking part in the study;
3. I am free to leave from the project at any time without any disadvantage;
4. Any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed;
5. The results of the project may be published but my anonymity will be preserved.

I agree to take part in this survey.

Signature of participant ____________________ Date _________

APPENDIX C

UNIVERSITY OF KWAZULU-NATAL

SCHOOL OF HEALTH SCIENCES

DISCIPLINE OF SPORT SCIENCE

Permission letter

19 September 2016

The District Educational Officer

Ministry of Education

Harare District

RE: PERMISSION TO CONDUCT RESEARCH STUDY

Dear Sir/Madam

I am writing to request for permission to conduct a Research Study with Head Coaches in High School in the Province of Harare. I am currently enrolled in the School of Physiotherapy, Sports Science and Optometry, in the Discipline of Sports Science at the University of KwaZulu Natal in South Africa. I am in a process of doing my Masters in Research. My study is entitled: ***Knowledge, attitudes and practices of plyometrics among High School coaches in Harare Province, Zimbabwe.***

I hope that the Ministry of Education will allow me to recruit Head Coaches from High Schools in Harare. The coaches who volunteer will complete a questionnaire and will be given a consent form that they will sign and return to the Primary Researcher at the beginning of the Survey. The research results will be absolutely confidential and anonymous.

Your approval to conduct this study will be greatly appreciated. I will follow up with a phone call and will be happy to answer any questions or concerns regarding the study. You may contact me at my email address : imunekani@yahoo.com .

If you agree, kindly submit a signed letter of permission on your letterhead acknowledging your consent and permission for the survey to be conducted.

Sincerely,

Munekani Ireen

Contact Number: +27718443822

APPENDIX D

UNIVERSITY OF KWAZULU-NATAL

FACULTY OF HEALTH SCIENCE

SCHOOL OF PHYSIOTHERAPY, OPTOMETRY & SPORTS SCIENCE

DISCIPLINE OF SPORTS SCIENCE

UNIVERSITY OF KWAZULU-NATAL

Questionnaire

Knowledge, attitudes and practices of plyometrics among High School coaches in Harare Province, Zimbabwe.

PERSONAL INFORMATION:

Participant Number _________

1. Are you willing to participate in this study? By ticking "yes" you are implying informed consent to participate.

Yes	
No	

2. Which category below describes your age?

17 or younger	
18 – 20	
21 – 29	
30 - 39	
40 - 49	
50 - 59	
60 or older	

3. Do you have your athletes perform plyometric training exercises as part of a training plan?

Yes	
No	

4. If you answered "No" to question 3, please briefly elaborate on why you do not:

____

____

____

____

5. If yes, who instructs and implements the training program?

Coach (yourself)	
Assistant coach	
Certified Strength and Conditioning coach	
Nurse	
Athletic trainer	
Other (Please specify)	

DEMOGRAPHICS:

6. Are you male or female?

Male

Female

7. Please tick all sports that you coach.

Soccer (Girls)	
Soccer (Boys)	
Volleyball (Girls)	
Volleyball (Boys)	
Track and Field (Girls)	
Track and Field (Boys)	
Netball (Girls)	
Handball (Girls)	
Handball (Boys)	
Basketball (Girls)	
Basketball (Boys)	
Tennis (Girls)	
Tennis (Boys)	
Table Tennis (Girls)	

Table Tennis (Boys)	
Swimming/Diving (Girls)	
Swimming/Diving (Boys)	
Waterpolo (Girls)	
Waterpolo (Boys)	
Gymnastics	
Baseball	
Cricket	

8. Have you ever been a competitive athlete at the high school, college, or professional level?

Yes	
No	

9. If yes, did you ever perform plyometric training exercise as part of your warm up or sport?

Yes	
No	

10. Have you had any formal training in plyometric exercise?

Yes	
No	

11. If yes, please elaborate on what type:

____

____

12. How many years have you been coaching?

0 – 5 years	
5 – 10 years	
10 – 15 years	
15 – 20 years	
20 or more years	

13. Did you graduate college with any of the following degrees?

Athletic Training	
Physical Therapy	
Fitness and wellness	
Strength and Conditioning	
Exercise Science	
None of the above	

PLYOMETRIC TRAINING:

(Choose the best answer)

14. The primary goals of plyometric exercise are?

Increase in heart rate and lung function as well as increase in aerobic endurance	
Maximal output and increase in oxygen transportation throughout the body (VO2max)	
Maximal jumping ability and maximal power output	
Maximal jumping ability and anaerobic endurance	
Do not know	

15. Plyometric exercises should be performed in the following manner:

Slow-controlled manner	
Explosive movement	
Fast-controlled manner	
Do not know	

16. Plyometrics heavily rely on all of the following physiological effects **EXCEPT:**

Stretch-Shortening cycle (active stretch of a muscle followed by an immediate shortening of that same muscle)	
Reciprocal inhibition (muscles on one side of a joint relaxing to accommodate contraction on the other side of that joint) example, Quadriceps relaxing to accommodate harmstring contraction.	
Reflexes	
Do not know	

17. Advantages of Plyometric Exercise include all of the following **EXCEPT:**

Decrease muscle reflex inhibition	
Increase muscle tension receptor sensitivity	
Increase muscle tension	
Decrease muscle lengthening sensitivity	
Do not know	

18. When designing progression in a plyometric training program, all of the following should be included **EXCEPT:**

Intensity (How long will the program be)	
Volume (How many exercises are being done in a program)	
Recovery (How long are the rests between exercises)	
Individual age	
Do not know	

19. Low intensity exercises should contain around how many foot touches?

Around 100	
Around 400	
Around 600	
Around 900	
Do not know	

20. The proper rest ratio when performing plyometrics is:

1:5	
1:2	
1:10	
1:1	
Do not know	

21. Within plyometric exercise, an increase in power output (ability of muscle to produce a force) is directly related to:

Increase in muscle fibre size	
Increase in heart and lung output	
Decrease in body weight	
Increase in type 1 muscle fibres	
Do not know	

22. Plyometric training has been shown to reduce which of the following common injuries in female athletes?

Knee posterior cruciate ligament (PCL) tears	
Muscle strains	
Ankle sprains	
Knee anterior cruciate ligament (ACL) tears	
Do not know	

23. Do you believe that female athletes land from a vertical jump differently from male athletes?

Yes	
No	

24. Do you believe female athletes have a greater risk of ACL injuries compared to their male counterparts?

Yes	
No	

25. Plyometric exercise is often a component of all the following programs **EXCEPT:**

Stabilization (ability to maintain one's balance)	
Endurance (how long an individual can perform a specific exercise)	
Power (how quickly a force can be exerted within a muscle)	
Strength (how much force your muscles can produce)	
Do not know	

26. The rapid switch from an eccentric contraction to a concentric contraction is known as:

Amortization phase	
Peak Power phase	
Recruitment phase	
Loading phase	
Do not know	

27. Proprioceptive ability within plyometric exercise emphasizes the importance of:

Muscle Tension Receptors and Skin Pressure Receptors	
Muscle tension Receptors and Skin Temperature Receptors	
Muscle Tension receptors and Muscle Lengthening Receptors	
Muscle Lengthening Receptors and Type 1 and 2 muscle fibers	
Do not know	

28. To effectively progress an athlete through plyometric training, which is the correct order to progress an athlete?

Power, Stabilization, Strength	
Strength, Power, Stabilization	
Stabilization, Power, Strength	
Stabilization, Strength, Power	
Do not know	

29. Which of the following is **NOT** a plane of motion (Dynamic planes of motion that the body is capable of moving through)?

Sagittal (dividing the body into left and right halves)	
Oblique (dividing the body by angles)	
Frontal (dividing the body into a front and back)	
Transverse (dividing the body into top and bottom)	
Do not know	

30. Equal hip muscle activation ratios help control which other movement in the body?

Hip flexion and Extension	
Knock knee or Bow legged	
Trunk rotation	
Knee flexion or extension	
Do not know	

31. All of the following are signs that an individual is not ready to progress their training program **EXCEPT:**

Excessive bending at the waist during takeoff and landing	
Prolonged contact with the floor	
Fatigue	
If individual's knees are collapsing inward during takeoff and landing	
Do not know	

32. All of the following may occur if intensity is too high **EXCEPT:**

Tendonitis	
Unsafe drop of blood pressure	
Decreased ability to "explode" during jumping	
Excessive heaviness of the legs	
Do not know	

33. Would you prefer to use plyometric exercises in your training program more often?

Yes	
No	

34. If yes, please briefly elaborate

____

____

____

____

APPENDIX E

UNIVERSITY OF KWAZULU-NATAL

FACULTY OF HEALTH SCIENCE

SCHOOL OF PHYSIOTHERAPY, OPTOMETRY & SPORTS SCIENCE

DISCIPLINE OF SPORTS SCIENCE

Memorandum

Knowledge, attitudes and practices of plyometrics among High School coaches in Harare Province, Zimbabwe.

PLYOMETRIC TRAINING:

(Choose the best answer)

14. The primary goals of plyometric exercise are?

Increase in heart rate and lung function as well as increase in aerobic endurance	
Maximal output and increase in oxygen transportation throughout the body (VO2max)	
Maximal jumping ability and maximal power output	√
Maximal jumping ability and anaerobic endurance	
Do not know	

15. Plyometric exercises should be performed in the following manner:

Slow-controlled manner	
Explosive movement	√
Fast-controlled manner	
Do not know	

16. Plyometrics heavily rely on all of the following physiological effects **EXCEPT:**

Stretch-Shortening cycle (active stretch of a muscle followed by an immediate shortening of that same muscle)	
Reciprocal inhibition (muscles on one side of a joint relaxing to accommodate contraction on the other side of that joint) example, Quadriceps relaxing to accommodate harmstring contraction.	
Reflexes	√
Do not know	

17. Advantages of Plyometric Exercise include all of the following **EXCEPT:**

Decrease muscle reflex inhibition	
Increase muscle tension receptor sensitivity	
Increase muscle tension	
Decrease muscle lengthening sensitivity	√
Do not know	

18. When designing progression in a plyometric training program, all of the following should be included **EXCEPT:**

Intensity (How long will the program be)	
Volume (How many exercises are being done in a program)	
Recovery (How long are the rests between exercises)	
Individual age	√
Do not know	

19. Low intensity exercises should contain around how many foot touches?

Around 100	√
Around 400	
Around 600	
Around 900	
Do not know	

20. The proper rest ratio when performing plyometrics is:

1:5	√
1:2	
1:10	
1:1	
Do not know	

21. Within plyometric exercise, an increase in power output (ability of muscle to produce a force) is directly related to:

Increase in muscle fibre size	
Increase in heart and lung output	
Decrease in body weight	
Increase in type 1 muscle fibres	√
Do not know	

22. Plyometric training has been shown to reduce which of the following common injuries in female athletes?

Knee posterior cruciate ligament (PCL) tears	
Muscle strains	

Ankle sprains	
Knee anterior cruciate ligament (ACL) tears	√
Do not know	

23. Do you believe that female athletes land from a vertical jump differently from male athletes?

Yes	√
No	

24. Do you believe female athletes have a greater risk of ACL injuries compared to their male counterparts?

Yes	√
No	

25. Plyometric exercise is often a component of all the following programs **EXCEPT:**

Stabilization (ability to maintain one's balance)	
Endurance (how long an individual can perform a specific exercise)	√
Power (how quickly a force can be exerted within a muscle)	
Strength (how much force your muscles can produce)	
Do not know	

26. The rapid switch from an eccentric contraction to a concentric contraction is known as:

Amortization phase	√
Peak Power phase	
Recruitment phase	
Loading phase	
Do not know	

27. Proprioceptive ability within plyometric exercise emphasizes the importance of:

Muscle Tension Receptors and Skin Pressure Receptors	
Muscle tension Receptors and Skin Temperature Receptors	
Muscle Tension receptors and Muscle Lengthening Receptors	√
Muscle Lengthening Receptors and Type 1 and 2 muscle fibers	
Do not know	

28. To effectively progress an athlete through plyometric training, which is the correct order to progress an athlete?

Power, Stabilization, Strength	
Strength, Power, Stabilization	
Stabilization, Power, Strength	
Stabilization, Strength, Power	√
Do not know	

29. Which of the following is **NOT** a plane of motion (Dynamic planes of motion that the body is capable of moving through)?

Sagittal (dividing the body into left and right halves)	
Oblique (dividing the body by angles)	√
Frontal (dividing the body into a front and back)	
Transverse (dividing the body into top and bottom)	
Do not know	

30. Equal hip muscle activation ratios help control which other movement in the body?

Hip flexion and Extension	√
Knock knee or Bow legged	
Trunk rotation	
Knee flexion or extension	
Do not know	

31. All of the following are signs that an individual is not ready to progress their training program **EXCEPT:**

Excessive bending at the waist during takeoff and landing	√
Prolonged contact with the floor	
Fatigue	
If individual's knees are collapsing inward during takeoff and landing	
Do not know	

32. All of the following may occur if intensity is too high **EXCEPT:**

Tendonitis	√
Unsafe drop of blood pressure	
Decreased ability to "explode" during jumping	
Excessive heaviness of the legs	
Do not know	

APPENDIX F

Gatekeeper's Approval Letter

MINISTRY OF PRIMARY AND SECONDARY EDUCATION

"THE PROVINCIAL EDUCATION DIRECTOR
Telephone : 792671/9
Telex :22287
Fax : 796125

Ministry of Primary and Secondary Education
Harare Provincial Office
Box CY 1343
Causeway
Harare
Zimbabwe

RE: <u>Approval in Respect of Request to Conduct Research</u>

This letter serves to indicate that approval is hereby granted to Miss Ireen Munekani to proceed with Research in respect of the study:

<u>Knowledge, attitudes and practices of Plyometrics among High School Sport Coaches in Harare Province Zimbabwe.</u>

The researcher will negotiate appropriate and relevant time schedules with the schools involved to conduct the research. A copy of this letter must be presented to the School Principal that permission has been granted for the research to be conducted.

Permission has been granted to proceed with the above Research subject to the conditions listed below being met:-

1. The School Principal must be presented with a copy of this letter that would indicate that the researcher has been granted permission from the Ministry of Primary and Secondary Education to conduct the research study
2. The research may only be conducted after the High School Sports Coach agrees to being part of the Research.

The Ministry of Primary and Secondary Education wishes you success in this important undertaking and looks forward to receiving the findings of your Research Study.

Yours sincerely

E. Dhliwayo

Human Resources Director

Harare Metropolitan Province

PRIMARY AND SECONDARY EDUCATION
HUMAN RESOURCES (HRE PROV)
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