DEVELOPMENT OF PADDED BANDANA FOR TAKRAW PLAYERS

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A thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering

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I certify that the project entitled “Development Of Padded Bandana For Takraw Players” is written by Muhammad ‘Azri Bin Mohd Razi I have examined the final copy of this report and in my opinion, it is fully adequate in terms of language standard, and report formatting requirement for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This study focuses on the analysis of a headband which is called the bandana. Takraw player often used a bandana on the head just for covering their hair and to sweep sweat. Unfortunately, the bandana is much more unprotected compared to headband because it does not have a material that can absorb an impact from the ball thus can cause a severe injury after several times of heading. It is shown that the understanding of the head impact with this bandana wearing by players in a game is imminent to the biomechanics knowledge. The objective of this study is to identify the most suitable material of bandana and fabricate a bandana based on the result of the experiment that has been conducted. This study involved with 2 types of experiment, which the first experiment conducted on the force plate in order to find the most suitable material for bandana among the 3 types of test material. For the second experiment conducted on the skull prototype in order to compare the parameters between best material results from the previous experiment and a condition without using any test material. The expected result produces from the experiment is the value of material should be relatively closed to or higher or lower than the benchmark value according to each parameter. A material that satisfies each parameter of the experiment was proven as the best material for padded bandana for Takraw players.

ABSTRAK

Kajian ini memberi tumpuan kepada analisis headband yang dipanggil bandana. Pemain Takraw sering menggunakan bandana di kepala hanya untuk menutup rambut mereka dan untuk menyapu peluh. Malangnya, bandana adalah lebih kurang melindungi berbanding dengan headband kerana ia tidak mempunyai bahan yang boleh menyerap kesan dari bola dan boleh menyebabkan kecederaan yang teruk selepas beberapa kali melakukan tandukan. Ia menunjukkan bahawa pemahaman kesan kepala dengan bandana ini yang dipakai oleh pemain dalam permainan adalah pasti kepada pengetahuan biomekanik ini. Objektif kajian ini adalah untuk mengenal pasti bahan yang paling sesuai dan membuat semula bandana berdasarkan keputusan eksperimen yang telah dijalankan. Kajian ini terlibat dengan 2 jenis eksperimen, percubaan pertama yang dijalankan ke atas plat kuasa untuk mencari bahan yang paling sesuai untuk bandana antara 3 jenis bahan ujian. Percubaan kedua yang dijalankan ke atas prototaip tengkorak untuk membandingkan parameter antara keputusan terbaik dari bahan eksperimen sebelumnya dan keadaan tanpa menggunakan apa-apa bahan ujian. Hasil keputusan yang dijangka dari eksperimen adalah nilai bahan harus agak sama atau lebih tinggi atau lebih rendah daripada nilai penanda aras mengikut setiap parameter. Satu bahan yang memenuhi setiap parameter eksperimen telah terbukti sebagai bahan yang terbaik untuk dijadikan bandana dan dipakai oleh pemain Takraw.

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LIST OF SYMBOLS

g	Gravitational Force
m	Mass
m/s	Meter per second
a	Acceleration
F	Force
N	Newton
V	Velocity
t	Time
Px	Pixel
Fr/s	Frame per second
e	Coefficient of restitution

LIST OF ABBREVIATIONS

ISTAF	International Sepak Takraw Federation
HIP	Head Impact Power
FYP	Final Year Project
CCD	Charge-Coupled Device
IEPE	Integrated Electronic Piezoelectric
DAQ	Data Acquisition System
ASTM	American Society for Testing and Materials

CHAPTER 1

INTRODUCTION

1.1 Introduction

One of the activities that can give many benefits to human especially in generating health to our body are sports. Involving ourselves in sports can protect us from many diseases that can threaten our lives, apart from dieting. In Greece back on 776BC where the first Ancient Olympic games were held, history has proved that sporting activities has long been a part of human lifestyle (Swaddling, 2000). Until now, sports have become a global culture where it is being used as a symbol to unite the people around the world. Nowadays, the presence of sports is undoubted as an important medium for the world's development as it can generate a strong relation between countries, organizations and human.

Through this relation, an array of sports event is being held to promote peace and strengthen the relationship among human. This action produced many international sports icon and globally renowned athletes from different kind of sports. Apart from hard work, the emerged of these athletes are being helped by the involvement of technology in sports through the invention and creation of training attire as well as training equipment. Technology has long been part of sports development. The use of training attire can give a big impact not only to the performance of the athletes, but the sports itself.

Because of this situation, the demand of safety in developing training attire has increased. Sports organizations demand the use of the safety training attire of the training. The increase in demand is caused by many factors such as to improve the player's performance. Before the invention of safety training attire, the player's performance is not maintained as during the play, players might get an injury and their performance might not as well as before the injury happened. This situation not only affect the performance of players, but also can affect the performance of the whole team.

Therefore, the used of safety training attire would be great solutions to improve the player's performance. The protection of safety training attire is also one of the main factors that it is good demand. Safety is very important in every sporting activities and through the application of safety protection material, surely it will help a lot. These factors not only contributed to the player's performance, but make the training attire very efficient and reliable during training.

Nowadays, there are many types of safety training attire available in the market for almost kind of sports and one of the attire is the headband. The headband is being used by players for sports activities protection such as in soccer, tennis, basketball and Takraw. The basic concept of the headband is to absorb sweat and keep player's hair from reaching the eyes.

For an example, the NIKE headband that has been produced since 1992 when NIKE assumes the lead in apparel technology with NIKE F.I.T fabrics, build for comfort and protection during high-intensity outdoor workouts. Until now, this headband brand has been widely used for outdoor workout and games because of it revolutionize design.

Nike Dri-FIT is a type of fabric with high-performance, microfiber, polyester fabric wicks sweat away from the body and moves it to the fabric surface, where it evaporates. As a result, Dri-FIT fabric helps you stay dry and comfortable. Other than that, Nike also will ensure that they produce headband features a nice protective device which are usually made of polyester and spandex. Polyester fabrics and spandex are extremely strong. They also very durable which is resistant to most chemicals, stretching and shrinking, wrinkle resistant, mildew and abrasion resistant. These features ensure that headband used not only to absorb sweat and safe, but also it is a need to protect the user's head.

This study was conducted in order to analyze and produce a suitable bandana that can protect a Takraw player in a game from a severe injury that caused by several times of headings. Based on the same situation from early research by Tysvaer and Lochen in Norway (1991), they reported that former professional soccer players head the ball 2,000 times or more in their careers and it was assumed that heading of the ball contributed to a chronic brain injury similar to the injury in boxers. The findings about the material of bandana from this study should be satisfy and comply with the rules and regulation of Takraw games so that players are not prohibited to participate in a game. This is because, according to Sepak Takraw rules and regulation (ISTAF, 2007), any equipment that is designed to increase or reduce the speed of the ball, increase a player's height or movement or in any other way give an unfair advantage and that endangers himself/herself or other players shall not be permitted.

This study involved with 2 types of experiment Takraw ball drop, which the first experiment conducted on the force plate in order to find the most suitable material for bandana among the 3 types of test material which is corrugated cardboard, sponge and composite material that made up of polyurethane, plastic and rubber. For the second experiment conducted on the skull prototype in order to compare the parameters between best material results from the previous experiment and a condition without using any test material. The parameters involve in both experiments was velocity after impact, ball deformation, contact time and coefficient of restitution. Additional parameters that differentiate between the Experiment 1 and 2 are maximum impact force and brain acceleration respectively. The benchmark value for this experiment are produced from the value of Takraw ball drop on a force plate for experiment 1 and drop on the skull prototype for experiment 2.

The expected result produces from the experiment for the value of velocity after impact, coefficient of restitution and ball deformation of material should be relatively closed to the benchmark value, usage of material should increase the contact time from the benchmark value, the value of maximum impact force of material should lower than benchmark value, and the last one is the value of brain acceleration of material also should be lower than benchmark value. All of this will be explain detail in Chapter 4. A material that satisfies each parameter of the experiment was proven as the best material for padded bandana and can be wear by Takraw players as it comply with Sepak Takraw rules and regulations.

1.2 History of Sepak Takraw

‘Sepak Takraw’ was the name of an ancient game played in the Malay states and in the neighboring countries of Singapore and Brunei. It was created by the royal family of Malaysia about 500 years ago. The name itself comes from two different languages. ‘Sepak’ is Malay for ‘kick’ and ‘Takraw’ is a Thailand word for the rattan ball used in the game, which involved players standing in a circle keeping the ball in the air for as long as possible without using their hands. Variations of this were played in other Southeast Asian countries too where in Philipine it was called ‘Sepa Sepa’, in Myanmar, ‘Ching Loong’, in Indonesia, ‘Rago’ and in Laos, ‘Kator’. When it is born, it looked like Japanese ‘Kemari’, and some became a circle and a pole was kicked, and the number of times was being competed in. It looks very similar to the Japanese traditional game, ‘Kemari’ where the players form a loose circle and the number of times the ball is kicked before it touches the ground is counted.

In 1965 the game was unified into the present volleyball style with the addition of a net and the adoption of international rules. The International Sepaktakraw Federation (ISTAF) is responsible of all the Sepak Takraw organizations. Modern Sepak Takraw, or Takraw for short (also known as Kick Volleyball), began in Malaysia and is now becoming their national sport. It combines elements of Soccer, Footbag, Volleyball, Baseball, Badminton, Gymnastics and the ancient sport of Sepak Raga. Balls woven of rattan stems have primarily been replaced by woven synthetic balls, which are much safer and more durable. A Sepak Takraw player needs to be extremely good when dealing with the ball. Because even when using a more secure ball, a player can still be prone to injury and concussion if players often do head impact without using any protection. Until now, there is no effective head protection designed for Takraw players to reduce injury and concussion in the match. So, the players might have a problem when it comes to dealing with safety protection.

1.3 Problem Statement

Striking a Takraw ball can be a painful experience especially for the beginner and especially when the forehead or the inner or outer parts of the ankle the most commonly used areas of the body are used because these areas have little or no natural padding in the form of subcutaneous fat or muscle (Tithma & Boonchai, 2004). Normally in Takraw match, players will use a headband on their forehead in order to provide a protection from a continuous impact or a high speed impact of the Takraw ball. But due to the rules and regulation stated that, any equipment that is designed to increase or reduce the speed of the ball, increase a player's height or movement or in any other way give an unfair advantage and that endangers himself/herself or other players shall not be permitted (ISTAF, 2007). Basically only one type of headband that have been used by the player which is called bandana. They often used a bandana on the head just for covering their hair and to sweep sweat (Lizel Tyson, 2012). But a bandana is much more unprotected compared to headband because it does not have a material that can absorb an impact from the ball thus can cause a severe injury.

1.4 Project Objectives

There are two objectives have been defined in this study which is:

(i) To identify the most suitable material of bandana that can protect the head of player.
(ii) To fabricate a bandana which consist of the most suitable material that can be part of the bandana and protect the head of the player.

1.5 Scopes of study

The following scopes of the project are determined in order to achieve the objectives of the project:

(i) The research is only looking at the one type of the headband which is the bandana.

(ii) The research will stress on finding the suitable material to be a part of bandana that used by the Takraw player during the play.

(iii) The material of the bandana headband used is cotton.

(iv) The bandana headband' thickness same as the usual size which is around 2-4 mm.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will briefly explain about the previous design and concept of headband that have been used in Takraw sport which is a bandana, along with the information of the material used throughout the process.

This valuable information is very important to decide the best application for development of the new Takraw headband, bandana. It is known that there is a Takraw headband has been developed. Therefore, the previous inventions of Takraw headband are being set as a reference to get the best concept for prototyping a Takraw headband.

The previous inventions are also important to decide the materials and mechanism that need to be used in this bandana along with its functions to minimize any weakness in prototyping the Takraw headband. It is also important to determine the design concept that will be applied during designing the bandana.

2.2 Head Impact in Takraw sports

Takraw players most commonly sustain head injuries when a forcefully kicked ball strikes to the head. Using the head to direct the ball, which is called "heading the ball," is a common feature in a Takraw game. Most commonly, the forehead is used to head the ball although Takraw rules provide that any part of the head may be legally used to strike the ball. The technique of heading the ball is a learned skill that requires practice to master. Unfortunately, learning this skill involves several heads to ball impacts which may occur using improper technique (Victor L. Domingos, 2006).

During practice sessions, players are trained by coaches who use their labor and manual training technique to generate variations of ball motion to train players. Manual training might involve throwing the balls by hand, or hitting the balls with a wooden paddle to athletes for defense and offense drills. For three hours per day of training sessions, players may have to hit the ball repeatedly up to 300 times. Each time a player heads the ball, they in effect, has caused a minor traumatic event to the head. There is a cumulative effect of repeated minor head trauma, which can result in permanent brain damage (Victor L. Domingos, 2006).

A concussion is a trauma-induced change in mental status, with or without unconsciousness caused by an impact to the head or upper body, or by non-contact severe motion, such as whiplash. Its symptoms range from a mild headache, nausea, dizziness, vertigo and heightened sensitivity to light or sound, amnesia to prolonged unconsciousness. It is also believed that a person who has had one concussion is four to six times as likely to have a second concussion as a no concussed player. The second concussion is often significantly more severe than the first, even if the second impact is seemingly minor, because the brain has not completely healed from the first concussion yet. This is often called the second impact syndrome (SIS).

(Newman et al, 1999) conducted a study on the probability of a concussion due to head clashes in American Football. It was observed that head injury severity or probability correlates to the magnitude of the rate of change of kinetic energy that the head undergoes during an impact. Based on this, a HIP equation was derived and its relation to the probability of concusion is established.

2.3 The Sepak Takraw Ball

Even though the size of Takraw ball is much smaller than a soccer ball, but a Takraw player often can get an injury from it. Like balls for football, basketball and others, the Takraw ball is spherical in shape. However, what distinguishes a Takraw ball from other balls are the method by which it is manufactured and the way it looks. A Takraw ball is made by interweaving rattan strips to produce a spherical ball, so it looks like a small spherical basket, which is the literal means of “Takraw” in Thai. A Thai Takraw ball is unique in that it has twenty interweaving crossovers and twelve corresponding apertures (Boonchai Lorhpipat, 1989).

Sepak Takraw balls are very different in size, material, and structure from others balls used in the sports. Sepak Takraw balls that are used to test in this study are the official competition balls (Marathon Model MT 908) which are 0.39 pounds in weight. The balls have a hollow spherical shape 5 inches in diameter with twelve pentagons-shaped holes around the ball surface (see Fig 1.1). The area of each hole is 0.43 square inches. The ball is made from woven synthetic rattan material with a soft rubber outer surface which has good bouncing characteristics and shock absorption (B. Lorhpipat and B. Lorpipatana, 2007)

Based on the site by the Sepak Takraw Association, Takraw balls were originally woven from rattan like in the figure 2.1 but in 1982 a Thai engineer revolutionized the sport by introducing woven synthetic (plastic) balls. Today, almost all players around the world are using synthetic Takraw balls such as in figure 2.2.

Figure 2.1: A woven rattan Sepak Takraw ball

Source: commons.wikimedia.org (2005)

Diameter = 5 inches

Figure 2.2: Test Ball. Sepak Takraw Ball Officially Approved by International Sepak Takraw Federation (ISTAF) for Men's Events

Source: psingha.com.sg (2007)

Nowadays, there are many types of Takraw ball produced but the most important thing it is produced to reduce the force exerted on the players body but it is comply with the rules of the game as stated in the official international rules governed by the International Sepak Takraw Federation (ISTAF). The example type of Takraw ball that widely used in Canada is shown in Table 2.1.

Table 2.1: Types of Takraw ball produced in Canada

Product	**Description**
	NP200 – Beginner Takraw Ball • 145 grams • Viking purple with bright yellow center strip • Light weight, soft synthetic (very durable and will not tear break), loose weave • Training Takraw ball for beginner players • Preferred ball for elementary school age or beginner players of any age
	NP300 – Intermediate Training Takraw Ball • 155 grams • Pine green with bright orange center strip • Medium weight, medium hard synthetic, medium weave • Intermediate Player training ball for Elementary and Junior High School. • Preferred ball for free style solo or group circle game sessions
	NP300T – JHS Boys/Girls, HS Girl's and Women's Tournament Takraw Ball • 160 grams. • Slightly heavier weight, for better ball control • Medium tight weave, for a springier bounce • Most used ball, covering widest age range

	• Official Tournament Ball for: - Junior High School Boys & Girls (grades 7 - 9) - High School Girls (grades 10 - 12) - Women (post High School)
	NP G401 – HS Boy's Tournament Takraw Ball • 170 grams • Beige with brown center strip • Heavier wieght, for better ball control for more advanced players • Tightly woven, for a springier bounce which makes for a faster game • Official Tournament Ball for: - High School Boys (grades 10 - 12)
	NP G501 – Men's Pro Tournament Takraw Ball • 178 grams • Beige with dark brown center strip • Heavy weight, hard synthetic, very tight weave for superb bounce & ball control • Official ball of the Men's World Cup

Source: www.netprosports.com (2012)

Furthermore, the types of motion involved in Sepak Takraw, which can be described as a unique blend of gymnastics, volleyball, soccer, Hacky sack and martial arts, are specific to the sport of Sepak Takraw. See Figure 1.2 for the four main types of ball motion generated in Sepak Takraw: tossing, serving, setting, and spiking.

Figure 2.3: Four main types of Sepak Takraw ball movements generated by athletes include: a) Tossing b) Serving c) Setting and d) Spiking.

Source: Ontam (2010)

2.4 Basic Concepts of a Bandana

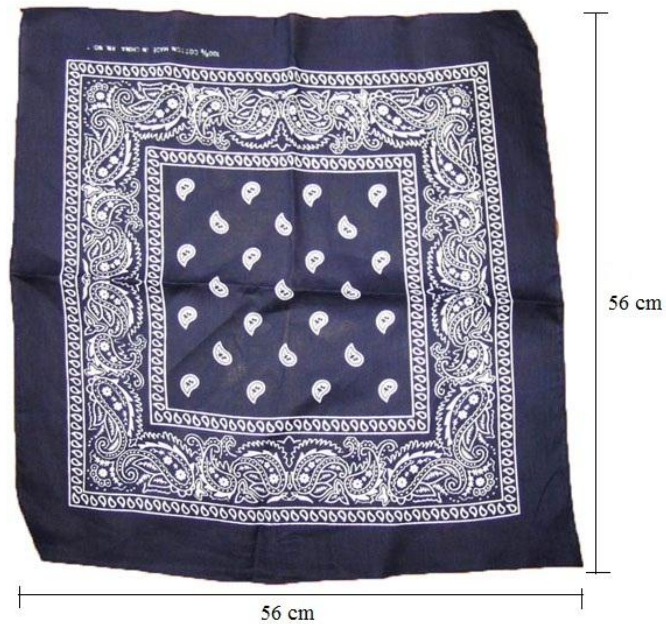

Figure 2.4: Figure 1.1: Dimension of normal bandana

The type of headband that only can be used in Takraw game until now is a bandana that looks like a piece of clothes that have none of protective features and made up of cotton used by Takraw player to cover their head as shown in Figure 2.4. The main concept of a bandana is same as a normal sports headband which is to absorb sweat and keep user's hair from reaching the eyes during workout or games (Lizel Tyson, 2012). It helps the user to improve the training efficiency and to fulfill their training period effectively without having much injury or concussion. A bandana should consist of at least one outer component of fabrics which elastic component being part of it, one inner component of flexible and shock absorbing material that attached to the outer component (Tithma & Boonchai, 2004).

Experts have recognized that appropriate headband would be useful to reduce the force of impact so that mild head injuries could be minimized. Such headgear would need to take into consideration not only shock absorption characteristics, but also the appearance and heat dispersion, which are important for voluntary acceptance and use. There has been considerable resistance to wearing protective headband since the perception is that they prohibit accurate ball placement and dampen the rebound speed of the ball as stated in the rules and regulation in Sepak Takraw sports, any equipment that is designed to increase or reduce the speed of the ball, increase a player's height or movement or in any other way give an unfair advantage and that endangers himself/herself or other players shall not be permitted (ISTAF, 2007).

So, in order to comply with the rules, several types of protective headband have been developed to protect the player's head from injury while heading the ball. These devices use soft padding, a combination of soft padding and rigid plastic.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter is the overview to do an experiment of head impact of player with a Takraw ball in a certain type of condition. Flowchart system detailing the task was drafted out. This flow chart shows the overall flow of project in step by step process.

The experiment is divided into two parts which is first experiment's objective is to identify the best materials that satisfy the parameters (velocity after impact, ball deformation and contact time) and also can reduce the maximum impact force. For the second experiment's objective is to compare the parameters between the best material chosen from first experiment and without using any material. In the second experiment also there will be an added parameter which is the amount of brain acceleration.

The equipments that are necessary to conduct this experiment is dummy skull, in order to demonstrate the player head, the point of impact and also a place to put a headband; a high speed camera, to record the movement of the ball; an accelerometer, to get a reading of brain acceleration when the head impact occurs; and also a force plate, to measure a force of the Takraw ball in a drop ball test.

The data that need to be collected from the experiment conducted in order to achieve the objective of the project is a brain acceleration by using the accelerometer when the head impact occurs, value of maximum impact force from the force plate when drop onto different types of materials, contact time of the ball and the head of the player when head impact occur and also to record the motion of impact in order to analyze the velocity after impact and deformation of the ball on the player head.

Methodology (Flow Chart)

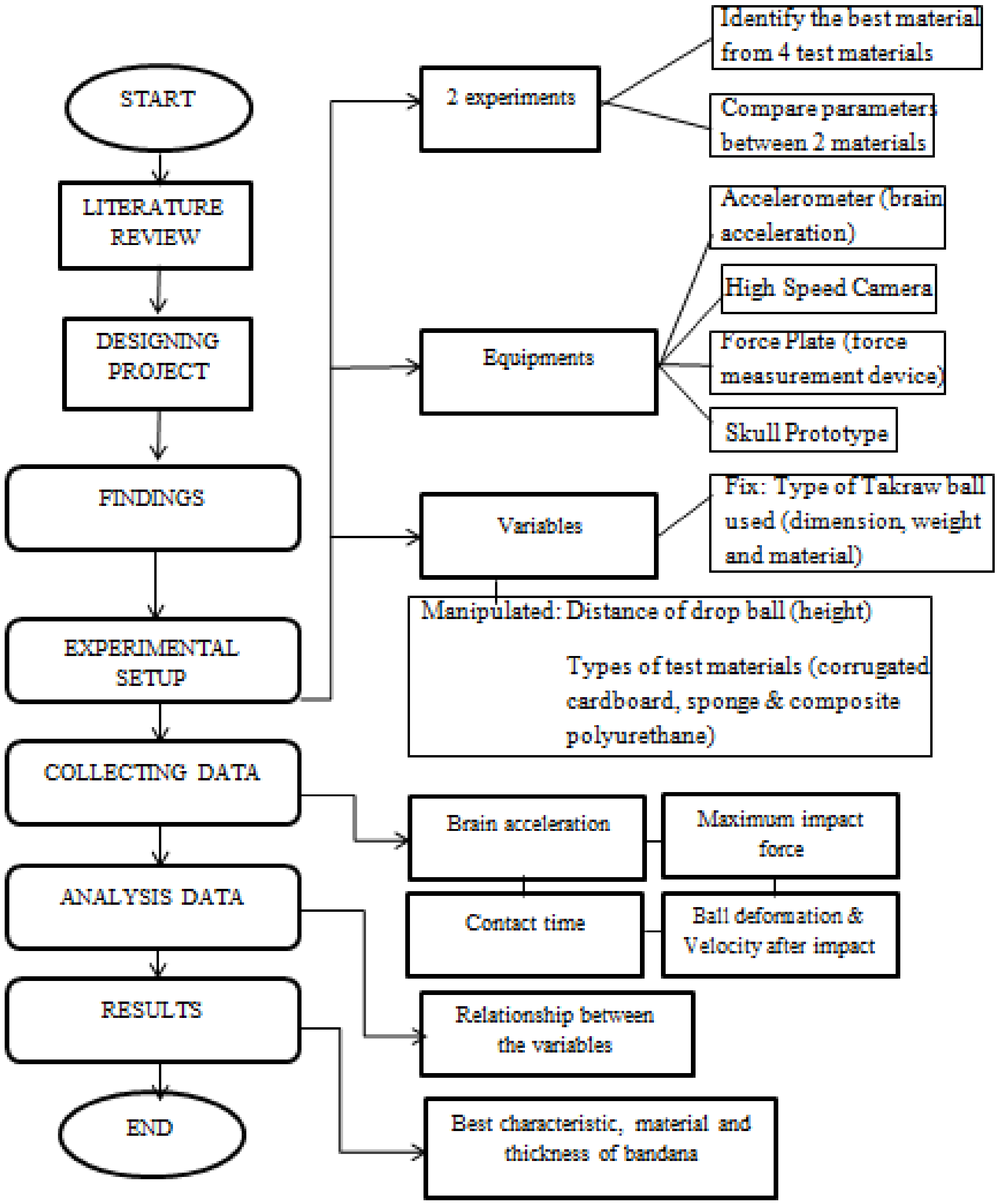

Figure 3.1: Flow Chart of Project

From the flow chart in figure 3.1 for an overview of the methodology in this research, the first thing to start the research is by finding the literature review that will be the source of the research and can support my justification. Literature reviews are the secondary sources which are a body of text that determines the aims to review the critical points of current knowledge including findings as well as theoretical and methodological contributions to this research.

After have found the source, the next step is to design the project. This process consist of design and construction phases. The results of the design process are drawings, calculations and all other information necessary to carry out the next phase. The next phase would normally analyze the findings from the literature review and planning for the equipment, device, tools or any process that required in the experimental setup.

In the experimental setup for the research, there will be two experiments which is a drop ball test, firstly, to identify the best material from 3 types of test materials (without material, corrugated cardboard, sponge and composite materials) and the second experiment are comparing the parameters between without materials and best material chosen from fthe first experiment. The equipments used in the research will be accelerometer, high speed camera, force plate and skull prototype. There will be two varied parameters in the experiments which is fixed and manipulated. The fix variables are a type of Takraw ball used in term of dimension, weight and materials. For the manipulated variables of this experiments are distance of drop ball (height) and also the types of test materials.

From the experiment conducted, the data will be expected to be collected are brain acceleration from the accelerometer, maximum impact force on the head, contact time of the ball, ball deformation and also velocity after impact of a ball from a recording of the motion of the impact. After experiment have been conducted, the relationship between the variables will be analyzed in order to come out with the result of best characteristic and material of the bandana.

3.2 Experiment Procedure

3.2.1 Experiment 1: Drop ball on Force Plate

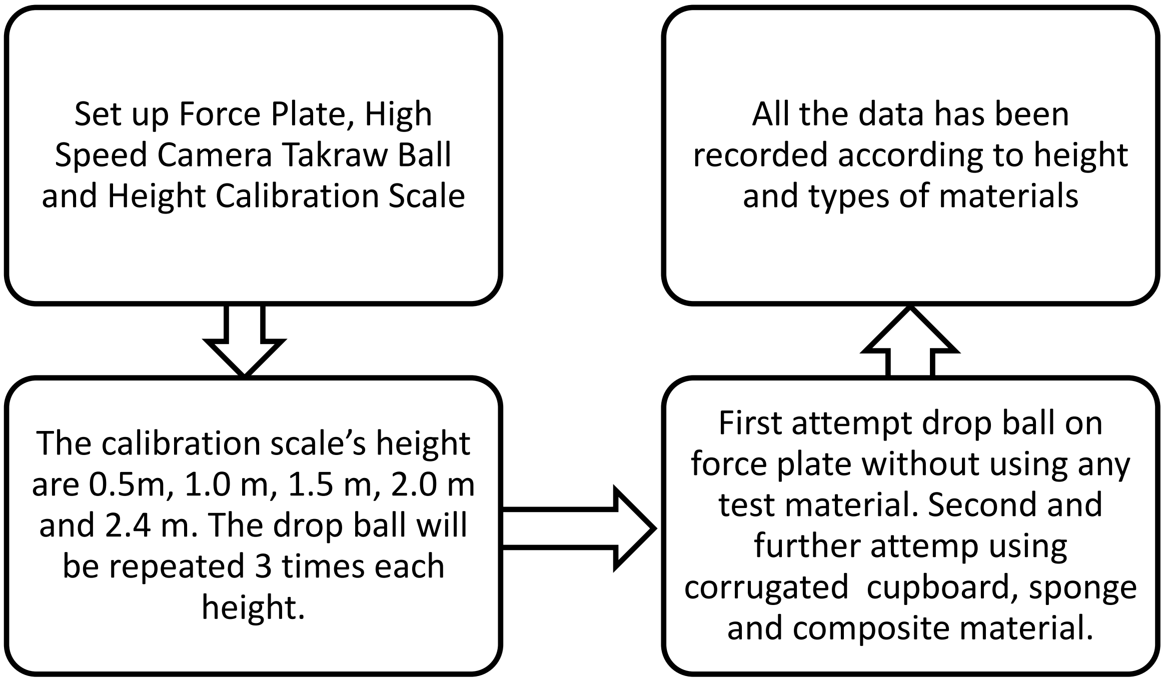

Figure 3.2: Experiment 1 flow procedure

This experiment's procedure was an idea from several journals that I have read and one of them is from Z. Taha et al (2008). The first thing to do is to set up the experiment equipment such as force plate, high speed camera, Takraw ball and the calibration scale. The calibration scale's height in this experiment is 0.5m, 1.0m, 1.5m, 2.0m and 2.4m. The highest height of calibration scale is 2.4m only due to the maximum height of the indoor laboratory where the experiment were conducted.

The drop ball will be repeated 3 times for each height in order to get an average reading for each height. The first attempt of drop ball on force plate is without using any test material. The second and following attempt is using the test material which is corrugated cardboard, sponge and composite materials. After all the material has been tested, all the data has been recorded according to the height and types of test materials.

Dropping a ball from a height also allows the effect of drag forces on the balls. The experiments were conducted indoors to discount the effects of air movement. A video camera was used to capture the ball's flight. A motion analysis software was used to measure the velocity on impact.

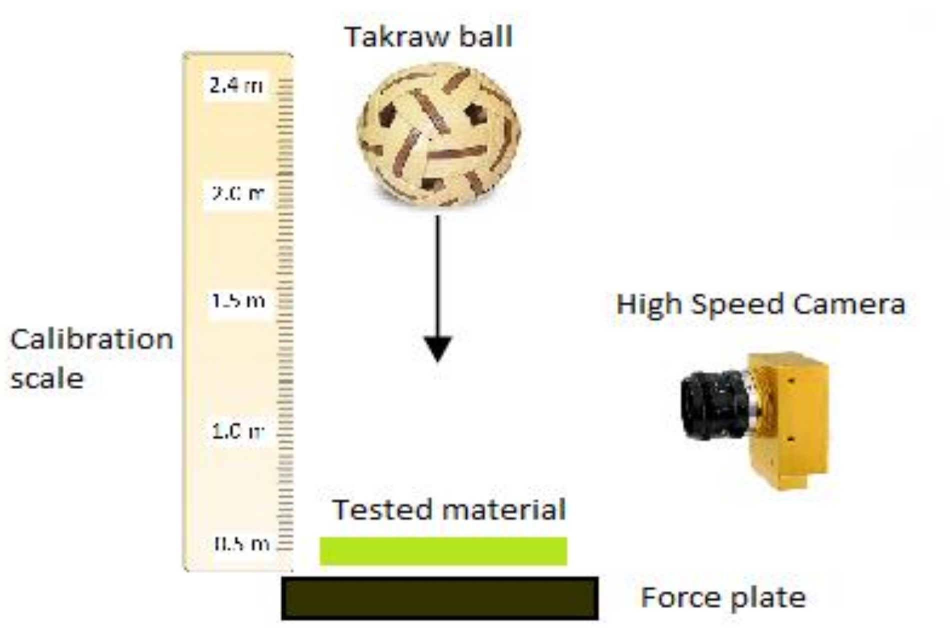

Figure 3.3: Experimental setup for experiment 1

3.2.2 Experiment 2: Drop ball on Skull Prototype

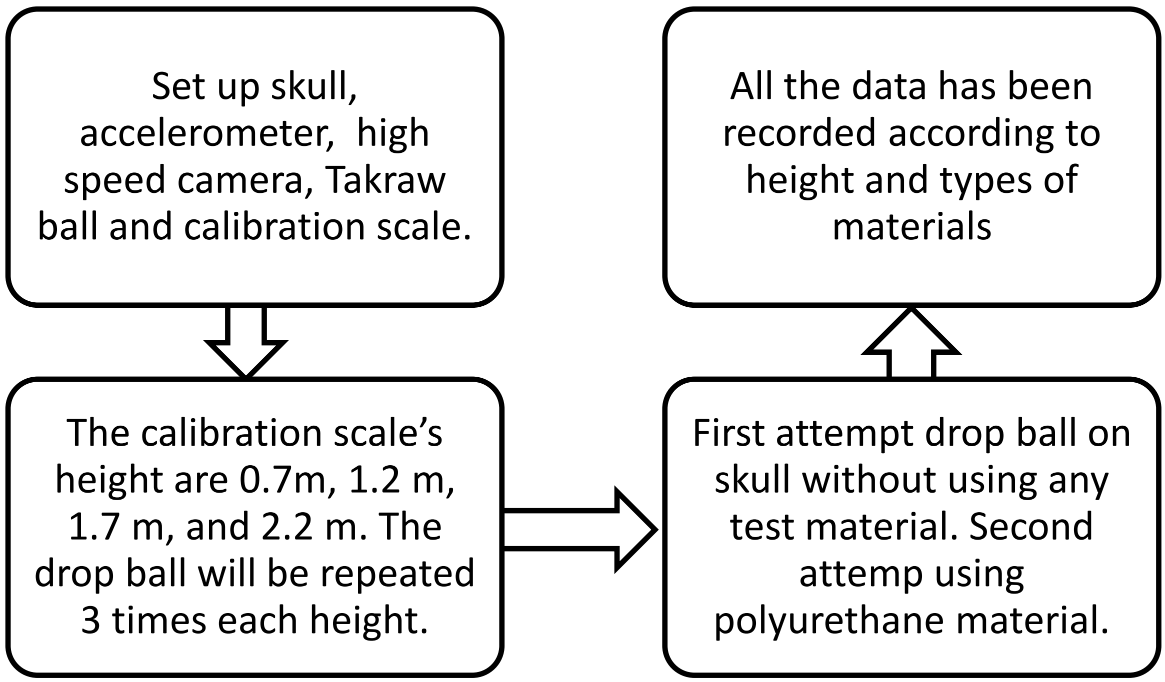

Figure 3.4: Experiment 2 flow procedure

This experiment 2's procedure also came from the same idea of the Experiment 1 and the steps involve were nearly the same as the steps involved in previous experiment procedure. Firstly, the experiment equipment was set up such as Force Plate, High Speed Camera, Takraw Ball and The Calibration Scale. The Calibration Scale's height in this experiment is 0.7 m, 1.2 m, 1.7 m and 2.4 m. The height used in this experiment were different from the previous experiment is due to the highest height of calibration scale is 2.2m only due to the maximum height of the indoor laboratory where the experiment were conducted plus the height of the Skull prototype.

The drop ball will be repeated 3 times for each height in order to get an average reading for each height. The first attempt of drop ball on the skull prototype is without using any test material. The second attempt is using the test material choosen from the previous experiment which is composite materials. After all the material has been tested, all the data has been recorded according to the height and types of test materials.

Dropping a ball from a height also allows the effect of drag forces on the balls. The experiments were conducted indoors to discount the effects of air movement. A video camera was used to capture the ball's flight. A motion analysis software was used to measure the velocity, contact time and ball deformation on the impact.

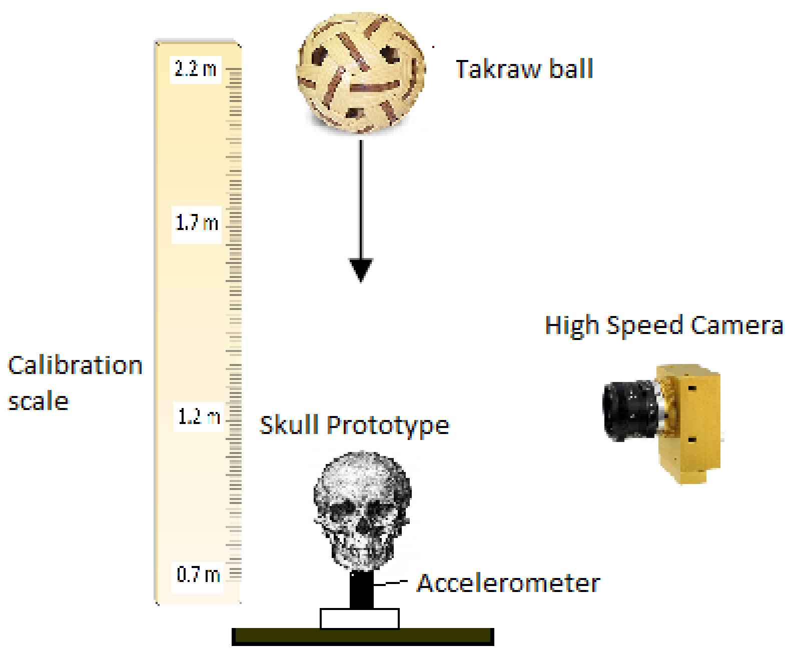

Figure 3.5: Experimental setup for Experiment 2

3.3 Experiment 1 and 2 Setup

Before conducting both experiment, the equipment that needs to be set up first are high speed camera, height calibration scale, force plate, accelerometer, skull prototype and Takraw ball. The test material that involve in the experiment 1 are corrugated cardboard, sponge and composite material. While the material involve in experiment 2 only the material that have been chose from the experiment 1.

3.3.1 High speed camera

A high-speed camera is a device used for recording fast-moving objects as a photographic image(s) onto a storage medium. After recording, the images stored on the medium can be played back in slow-motion. Early high-speed cameras used film to record the high-speed events, but today high-speed cameras are entirely electronic using either a charge-coupled device (CCD) or a CMOS active pixel sensor, recording typically over 1,000 frames per second into DRAM and playing images back slowly to study the motion for scientific study of transient phenomena (Kris Barch,1999). A high-speed camera can be classified as a high-speed film camera that records to film, a high-speed framing camera that records a short burst of images to film/digital still camera, a high-speed streak camera that records to film/digital memory or a high-speed video camera recording to digital memory.

The high speed camera used in the experiment is shown in the figure 3.6 which is silicon video camera model SV643C by EPIX which has 640 x 480 Global Shutter resolution was set up according the suitable height and angle to capture the motion of the ball impact with the test materials on the force plate. The frame rate of high speed camera that has been set according to the suitable video size was 400 frame/second for experiment 1 and 500 frame/second for experiment 2.

The software that have been used to record the impact motion of Takraw ball in the experiment by the High Speed Camera is XCAP by EPIX Inc. This software is a program for the PIXCI® imaging boards allowing capture, display, viewing, processing, printing, analysis, measurements, loading and saving of imagery.

Figure 3.6: EPIX SV643C camera

3.3.2 Height calibration scale

There are 5 levels of height that has been set up for the drop ball in experiment 1 which is 0.5 m, 1.0 m, 1.5 m, 2.0 m and 2.4 m as shown in the figure 3.7. The highest level is 2.4 m because of the limitation of maximum height of indoor laboratory where the experiment was conducted. For the experiment 2, there are only 4 levels of height that has been set up for the drop ball which is 0.7 m, 1.2 m, 1.7 m and 2.2 m. The highest level is 2.2 m in the experiment 2 because of the limitation of maximum height of indoor laboratory where the experiment conducted and also because of the height of skull prototype.

Figure 3.7: Height calibration scale

3.3.3 Data Acquisition and Accelerometer

An accelerometer is a device that measures proper acceleration. The proper acceleration measured by an accelerometer is not necessarily the coordinate acceleration which is rate of change of velocity. Instead, the accelerometer sees the acceleration associated with the phenomenon of weight experienced by any test mass at rest in the frame of reference of the accelerometer device. For example, an accelerometer at rest on the surface of the earth will measure an acceleration g= 9.81 m/s2 straight upwards, due to its weight. By contrast, accelerometers in free fall or at rest in outer space will measure zero. Another term for the type of acceleration that accelerometers can measure is g-force acceleration.

The accelerometer used in the experiment was PCB Piezotronics Model 356B11 Miniature Triaxial Accelerometer as shown in figure 3.7.

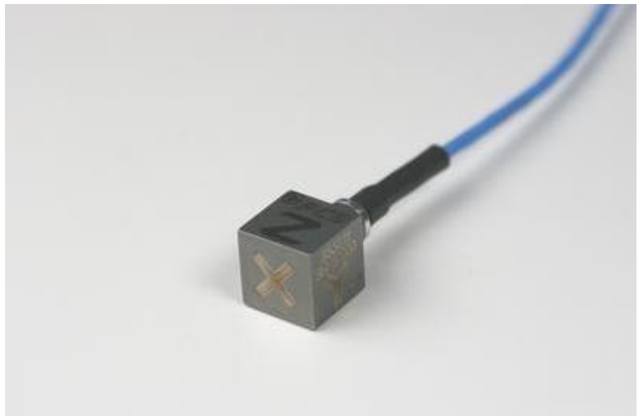

Figure 3.8: Miniature Triaxial Accelerometer model 356B11

The data acquisition used with the accelerometer in the experiment was model NI 9234 as shown in the figure 3.9. The NI 9234 is a four-channel C Series dynamic signal acquisition module for making high-accuracy audio frequency measurements from integrated electronic piezoelectric (IEPE) and non-IEPE sensors with NI CompactDAQ or CompactRIO systems. The NI 9234 delivers 102 dB of dynamic range and incorporates software-selectable AC/DC coupling and IEPE signal conditioning for accelerometers and microphones. The four input channels simultaneously digitize signals at rates up to 51.2 kHz per channel with built-in antialiasing filters that automatically adjust to your sampling rate. The software that has been used to analyze and interpret the data from accelerometer was DasyLab.

Figure 3.9: Data acquisition model NI 9234

3.3.4 Takraw ball

The Takraw ball used for this experiment was the normal Takraw ball used in the Takraw ball tournament which made up of plastic materials. The Takraw ball is then attached to the string where the string act as a holder of the Takraw ball at a certain height as shown in figure 3.10. The Takraw ball was pulled by string at a certain height through the pulley has been set up at the top center of the height calibration scale. The test material was set up on the force plate one after another and wait for the ball to be dropped.

Figure 3.10: Takraw ball attached to the string

3.3.5 Force Plate

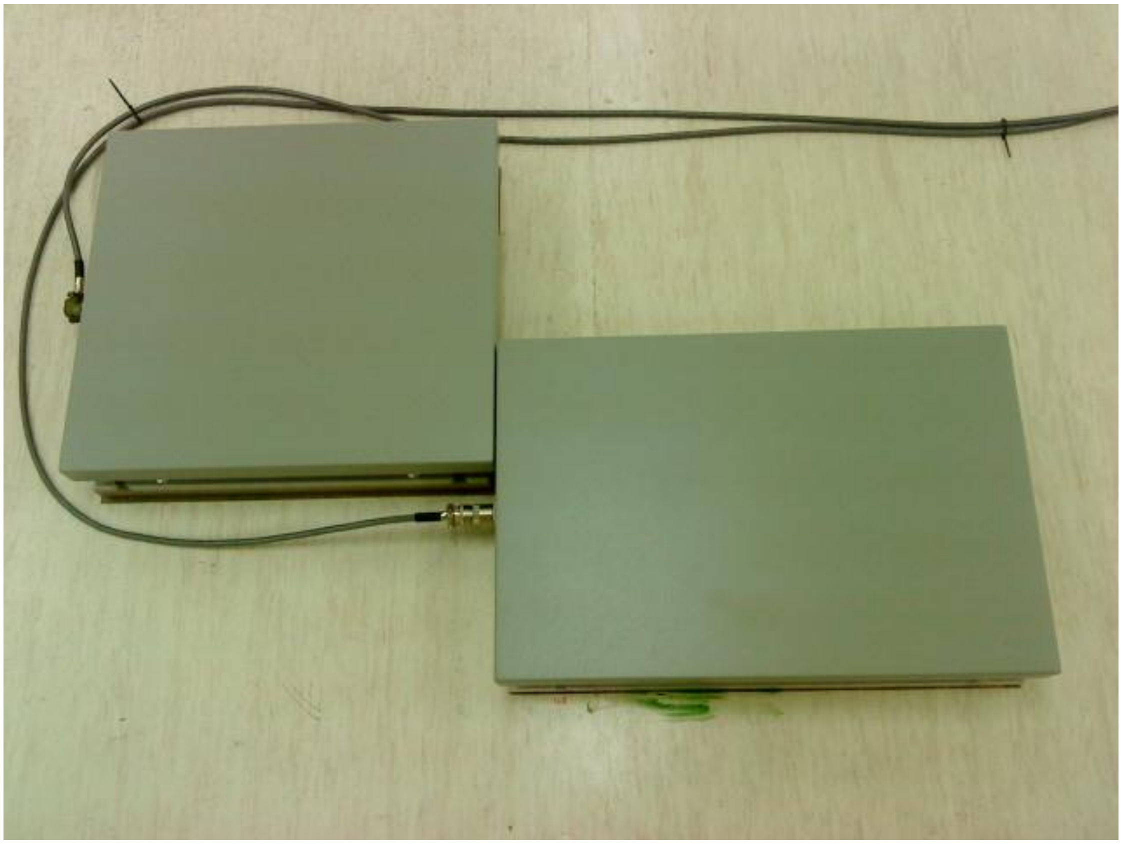

Figure 3.11: AMTI Force plate

Force platform or force plates as shown in figure 3.11, are measuring instrument that measure the ground reaction forces generated by a body standing on or moving across them, to quantify balance, gait and other parameters of biomechanics. The most common areas of application are medical and sports. Force platforms should be distinguished from pressure measuring systems that, although they too quantify center of pressure, do not directly measure the applied force vector. Pressure measuring plates are useful for quantifying the pressure patterns under a foot over time but cannot quantify horizontal or shear components of the applied force (Robertson DGE, 2004).

The measurements from a force platform can be studied either in isolation, or combined with other data, such as limb kinematics to understand the principles of locomotion. If an organism makes a standing jump from a force plate, the data from the plate alone is sufficient to calculate acceleration, work, power output, jump angle, and jump distance using basic physics. Simultaneous video measurements of leg joint angles and force plate output Can allow the determination of torque, work and power at each joint using a method called inverse dynamics.

The force plate used in the experiment is the AccuGait Walkway AMTI Force plate that is constructed of a lightweight but durable aluminium-foam composite and features line-up pins and quick latches that make for an effortless set-up and take-down as shown in figure 3.12. This force plate has a standard walkway is 2.9 meters long and it is only be used in Experiment 1 to find the maximum impact force because in Experiment 2 the force plate is substitute with the accelerometer in order to find the brain acceleration.

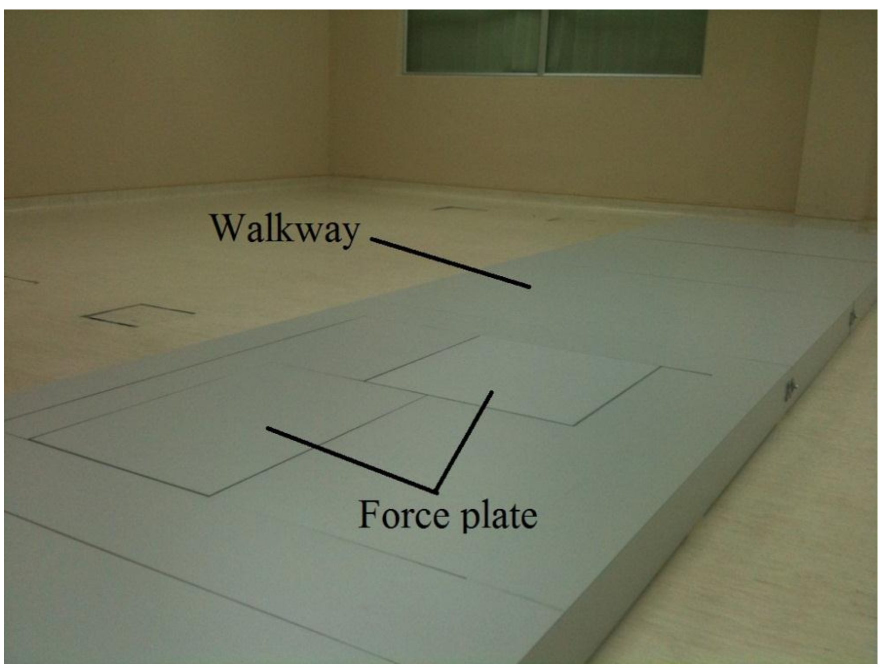

Figure 3.12: AccuGait Walkway AMTI Force plate used in the experiment

3.4 Experiment work out procedure

3.4.1 Experiment 1 work out procedure

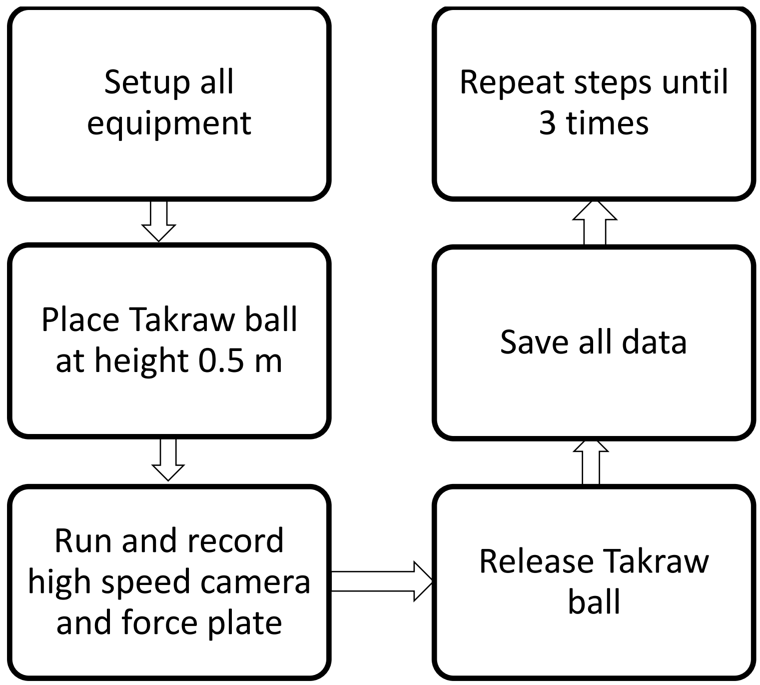

Figure 3.13: The flow process of experiment 1 work out procedure

The steps for conducting the experiment 1 involving 6 steps to be followed as shown in figure 3.13. The first step is to setting up all experiment equipments that are needed in conducting the experiment such as High Speed Camera, Force Plate, Takraw ball and the Calibration Scale. After all equipment have been set up and ready to conduct the experiment, the Takraw ball is placed at initial height of the Height Calibration Scale which is 0.5 m.

After that, run and record the High Speed Camera and the Force Plate and ready to release the Takraw ball. The Takraw ball is release when there is no movement or spinning of the Takraw ball. All the data of the impact Takraw ball with the material on the Force plate is recorded and save to the specific file location. This steps is repeated until 3 times to obtain the average value data of height 0.5 m and after that the whole flow process is repeated for following height which is 1.0 m, 1.5 m, 2.0 m and 2.4 m.

There will be expected that there is a source of error in the experiment that can affect the resulting data of the experiment. The source of error could be because of the human error during releasing the string that attached to the Takraw ball. When releasing the ball by hand using a string, the ball rotates slightly, causing the ball to lose some of its translational energy which in turn causes the ball to not bounce as high as it would be. Other than that, because of the Takraw ball has 12 holes and 20 intersection, the Takraw ball did not bounce correctly because of the uneven shape or surface of Takraw ball.

3.4.2 Experiment 2 work out procedure

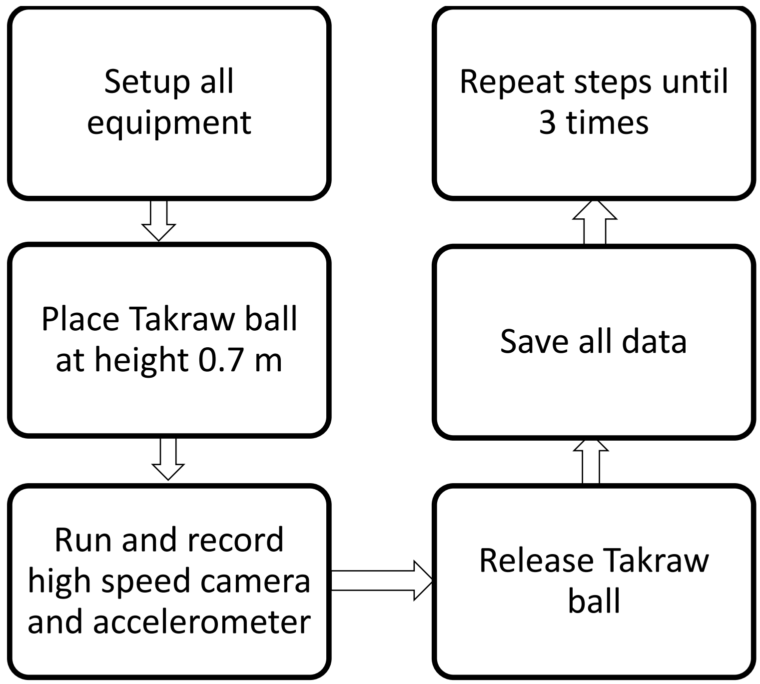

Figure 3.14: The flow process of experiment 2 work out procedure

In the experiment 2 works out procedure, the steps involved were nearly the same as the steps involved in previous experiment for work out procedure. There are 6 steps to be followed for conducting the experiment 2 as shown in figure 3.14. The first step is to set up all experiment equipment that are needed in conducting the experiment such as High Speed Camera, Accelerometer, Takraw ball and the Height Calibration Scale. After all equipment have been set up and ready to conduct the experiment, the Takraw ball is placed at initial height of the Height Calibration Scale which is 0.7 m. After that, the High Speed Camera and the Force Plate was run and record and ready to release the Takraw ball. The Takraw ball is release when there is no movement or spinning of the Takraw ball. All the data of the impact Takraw ball with the material on the Force plate is recorded and save to the specific file location. This steps is repeated until 3 times to obtain the average value data of height 0.7 m and after that the whole flow process is repeated for following height which is 1.2 m, 1.7 m and 2.2 m.

The source of error in this experiment also is quite the same as the source of error in the previous experiment. This is because in Experiment 2, in order to put the Takraw ball at the certain height using a string attached to the ball, human assist is also needed so that the experiment can run smoothly. But when human assist were used in the experiment there will be high possibility that the human will be done some error during conducting the experiment. This is because, when releasing the ball by hand using a string, the ball rotates slightly, causing the ball to lose some of its translational energy which in turn causes the ball to not bounce as high as it would be. Other than that, because of the Takraw ball has 12 holes and 20 intersection, so the Takraw ball did not bounce correctly because of the uneven shape or surface of Takraw ball.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

In this chapter, the experimental result obtained from the Experiment 1 and Experiment 2 will be presented and discussed. In the initial setup for Experiment 1, the 3 test material were tested with drop ball of Takraw ball in 5 different level of height in order to identify the velocity after impact, ball deformation, contact time, coefficient of restitution and maximum impact force of each materials. While the initial setup for experiment 2 is just only involved the test material chosen from the result of Experiment 1 and it will be tested in 4 different level of height in order to find the same parameter with Experiment 1 but the maximum impact force parameter were replaced with brain acceleration parameter. The result from Experiment 1 were obtained by varied parameters the type of test material and the height of drop ball whereas for Experiment 2 only the height of drop ball. In the end, the finding the most suitable material for development of padded bandana in future through the relationship of result obtained was been be defined.

4.2 Result data from Experiment 1

The main objective of this experiment is to identify the best materials that satisfy the parameters which is velocity after impact, ball deformation, contact time and also can reducing the maximum impact force. The design of this experiment using 3 different test materials which is corrugated cardboard, sponge and composite material and a condition without using any test material.

4.2.1 Data from Force Plate

From the experiment have been conducted using 3 different materials, and each of the material was tested by dropping a Takraw ball on it 3 times for each height, the impact force between the Takraw ball and the materials have been recorded by Force Plate. The result below from table 4.7 show the maximum impact force of 3 materials and a condition without using any test material according to height.

Table 4.1: Maximum Impact Force

Maximum impact force (N)				
Height	**w/o Headband**	**Cardboard**	**Sponge**	**Composite material**
0.5	216.4593	187.4805	176.5470	170.2541
1	272.4522	276.6935	274.9009	247.7352
1.5	319.0515	315.5867	319.5243	305.1993
2	361.5939	352.2235	378.1689	349.9748
2.4	370.6836	403.7133	399.6687	358.0992

The quality characteristics for the material that is needed in term of maximum impact force is the material should have a lower value than the benchmark value produce by a condition without using any test materials. This is because, the material should be reduce the impact force of the Takraw ball in term of safety of the Takraw player when heading the ball.

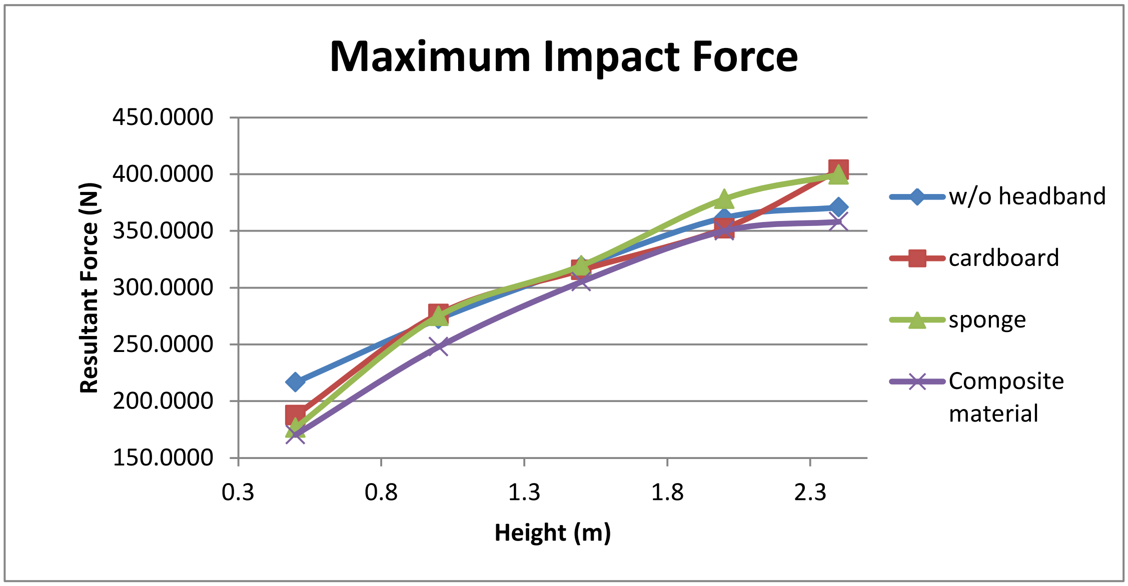

Figure 4.1: Maximum impact force graph

From the graph in figure 4.6 it shows that, most of the materials produce a close value of maximum impact force with the benchmark value which is 370.68 N at height 2.4 m. But the material that produce the lowest value and lower than the benchmark value is composite material which is 358.10 N at height 2.4 m. This is followed by sponge and carboard material which produce 399.67 N and 403.71 N at height 2.4 m respectively.

4.2.2: Data from High Speed Camera

The experiment have been conducted using 3 different materials, and each of the material was tested by dropping a Takraw ball on it 3 times for each height, the motion of impact of the Takraw ball and the materials have been recorded by High Speed Camera. The result below from table 4.3 show the velocity after impact of 3 materials and a condition without using any test material according to height.

Table 4.2: Velocity after impact Experiment 1

Velocity after impact (m/s)				
Height	**w/o Headband**	**Cardboard**	**Sponge**	**Composite material**
0.5	0.7791	0.6678	0.5988	0.7319
1	1.0685	0.9795	0.9537	1.0646
1.5	1.3356	1.1798	1.1533	1.3307
2	1.5805	1.3579	1.3529	1.5747
2.4	1.7808	1.5137	1.5525	1.7743

The quality characteristics for the material that is needed in term of velocity after impact is the material should be producing a same or very slightly different value from the benchmark value of velocity produce by a condition without using any test materials. This is because it means the material is reducing the force from the ball but does not change the velocity of the ball after impact whether improve or reduce the performance of the Takraw player.

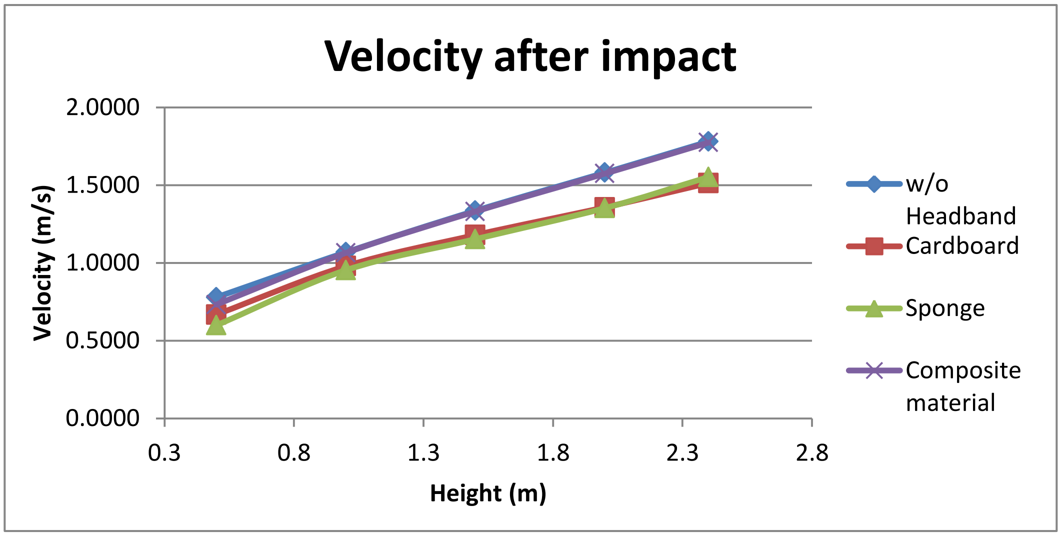

Figure 4.2: Velocity after impact graph Experiment 1

From the graph in figure 4.2 it shows that, most of the materials produce a value of velocity after impact quite same value with the benchmark value which is by a condition without any test materials which is 1.78 m/s at height 2.4 m. But the material that produce a value very close to the benchmark value of velocity after impact is composite material which is 1.77 m/s at height 2.4 m followed by material sponge and cardboard. The composite material choosen as the best material in term of velocity after impact because it produce a lower value than the benchmark value and it means it reduce the impact force from the ball but not effecting the performance of the Takraw player whether by improve or reducing their performance.

The result below from table 4.4 show the ball deformation of 3 materials and a condition without using any test material as a benchmark value.

Table 4.3: Ball deformation Experiment 1

	Ball deformation (m)			
Height	**w/o Headband**	**Cardboard**	**Sponge**	**Composite material**
0.5	0.0072	0.0122	0.0100	0.0116
1	0.0100	0.0139	0.0144	0.0128
1.5	0.0111	0.0156	0.0155	0.0122
2	0.0139	0.0184	0.0205	0.0139
2.4	0.0139	0.0200	0.0205	0.0139

The quality characteristics for the material that is needed in term of ball deformation is the material should be producing a low value or near with the benchmark value of ball deformation produce by a condition without using any test materials. This is because, from the equation $F = kx$, the higher the deformation occur, the lower the force produce as there is energy loss during the ball deformation. When the force reduced, this prevent the player from having severe injury due to the head impact during heading without affecting the performance of player.

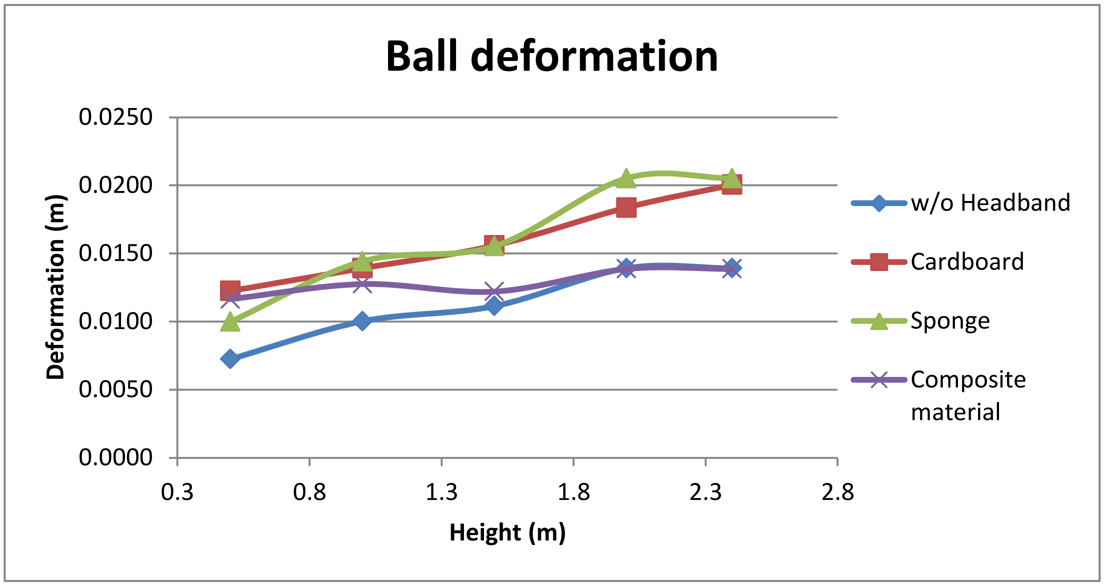

Figure 4.3: Ball deformation graph Experiment 1

From the graph in figure 4.3 it shows that, most of the materials producing a higher value of ball deformation compared to benchmark value which produce the lowest value. But in term of ball deformation, the material that shows the lowest or near the benchmark value is composite material which is 0.0139 m at height 2.4 m and the benchmark value is also 0.0139 m at height 2.4 m. This is followed by cardboard and sponge material which produce 0.0200 m and 0.0205 m at height 2.4 m respectively.

The result below from table 4.5 show the contact time of 3 materials and a condition without using any test material as a benchmark value.

Table 4.4: Contact time Experiment 1

Contact time (s)				
Height	**w/o Headband**	**Cardboard**	**Sponge**	**Composite material**
0.5	0.0208	0.0225	0.0383	0.0325
1	0.0140	0.0225	0.0383	0.0300
1.5	0.0140	0.0233	0.0375	0.0300
2	0.0140	0.0225	0.0333	0.0275
2.4	0.0140	0.0225	0.0308	0.0250

The quality characteristics for the material that is needed in term of contact time is the material should be producing a higher value from the benchmark contact time produce by a condition without using any test materials. This is because, according to equation F = ma, it means that, the higher contact time produce by the material, the lower the force exerted.

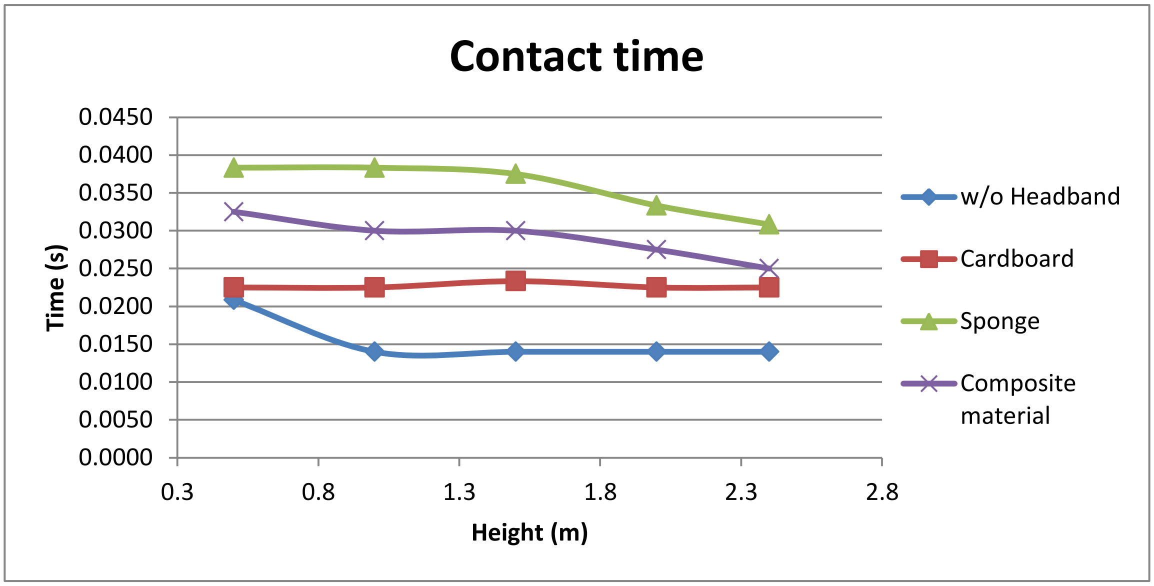

Figure 4.4: Contact time graph Experiment 1

From the graph showed in figure 4.4, the highest contact time produce is by sponge material which is 0.0308 s at height 2.4 m followed by composite material is 0.0250 s at height 2.4 m, cardboard is 0.0225 s at height 2.4 m and a condition without material is 0.0140 s at height 2.4 m.

The result below from table 4.6 show the coefficient of restitution of 3 materials and a condition without using any test material as a benchmark value.

Table 4.5: Coefficient of restitution Experiment 1

	Coefficient of restitution (ratio)			
Height	**w/o Headband**	**Cardboard**	**Sponge**	**Composite material**
0.5	0.6484	0.5664	0.5000	0.6471
1	0.6489	0.5950	0.5972	0.6667
1.5	0.6748	0.5954	0.5843	0.6820
2	0.6829	0.6040	0.5981	0.6829
2.4	0.7045	0.5965	0.6249	0.6904

The quality characteristics for the material that is needed in term of coefficient of restitution is the material should have a same value or close to the benchmark value produce by a condition without using any test materials. This is because, the characteristic that needed from the material is same as the benchmark value so that it does not change the performance of the Takraw player whether improve or reduce their performance by an elastic or inelastic characteristic of the material. The value of coefficient of restitution can be obtained by dividing the velocity after impact and velocity before impact of the ball with material by using the following equation:

$$e = \frac{(v_2 - v_1)}{(v_1 - v_2)}$$

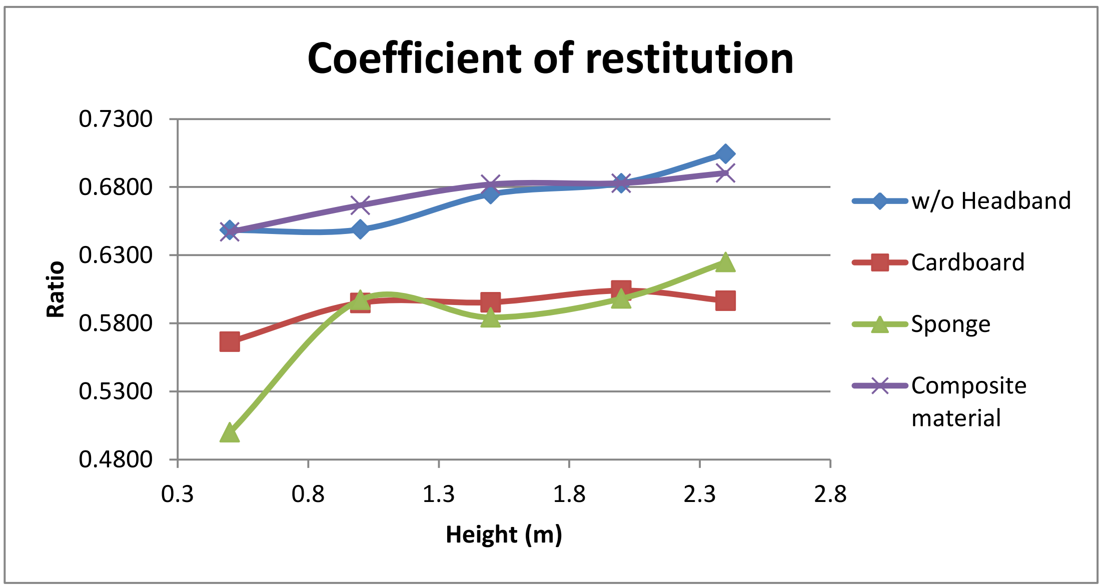

Figure 4.5: Coefficient of restitution graph Experiment 1

From the graph in figure 4.5 it shows that, the material that produce a value of coefficient of restitution that same or close to the benchmark value is a composite material which is 0.6904 at height 2.4 m and a benchmark value is 0.7045 at height 2.4 m. This is followed by sponge and cardboard material which is 0.6249 and 0.5965 at height 2.4 m respectively.

Table 4.6: Experiment 1 conclusion

Parameter	Observation
Velocity after impact	Composite material produce closest value to without headband
Ball deformation	Composite material produce closest value to without headband
Contact time	Sponge produce highest value
Coefficient of restitution	Composite material produce closest value to without headband
Maximum Impact Force	Composite material produce lowest value than other materials

Based on data recorded, composite material was choose as the best material according to each parameters as shown in table 4.8. Because of that, composite material has been choose as the best material for experiment 1 and will be test in experiment 2.

4.3 Result data from Experiment 2

The main objective of this experiment is to compare the parameter between the best material chosen from experiment 1 which is composite material and a condition without using any test material on the skull prototype. The parameter that will be tested in this experiment is same as the experiment 1 which is velocity after impact, ball deformation and contact time but there is an additional parameter which is finding the amount of brain acceleration. The design of this experiment using only one test materials that has been chosen from the experiment 1 which is composite material and a condition without using any test material.

4.3.1 Data from Accelerometer

From the experiment have been conducted using composite material and a condition without using test material, and the test conducted by dropping a Takraw ball on the composite material and a condition without using test material 3 times for each height, the brain acceleration that represent by skull prototype have been recorded by Accelerometer. The result below from table 4.13 show the brain acceleration of composite materials and a condition without using any test material according to height.

Table 4.7: Brain acceleration

	Brain Acceleration (g)		
Height (m)	**W/O Bandana**	**With Bandana (Composite material)**	**Reduction percentage**
0.7	8.2667	2.5986	69%
1.2	12.2985	4.1016	67%
1.7	16.0775	5.2692	67%
2.2	19.7693	5.6637	71%

The quality characteristics for the composite material that is needed in term of brain acceleration is the composite material should have a lower value than the benchmark value produce by a condition without using any test materials. This is because, the composite material should be reduce the brain acceleration cause by the impact of the Takraw ball and the head in term of safety of the Takraw player when heading the ball.

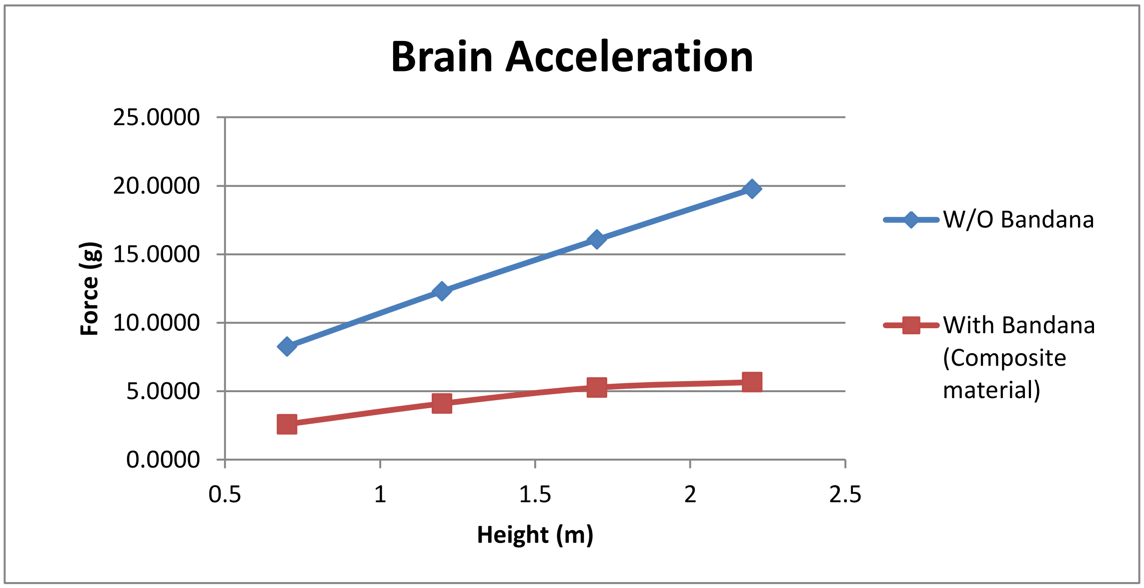

Figure 4.6: Brain acceleration graph

From the graph in figure 4.11 it shows that, clearly the composite material reduce or produce a more lower value of brain acceleration which is 5.66 [g] at height 2.4 m compared to a benchmark value by a condition without using test material which is 19.77 [g] at height 2.4 m. As in the reduction percentage of brain acceleration, composite material also produce a good result by the percentage of reduction increase as the height increase and can reach to 71% of reduction at height 2.4 m. This prove the result from experiment 1 that the composite material reduce the maximum impact force of the ball as well as the brain acceleration during head impact with the Takraw ball.

4.3.2 Data from High Speed Camera

From the experiment have been conducted using composite materials and a condition without test material, and the composite material was tested by dropping a Takraw ball on it 3 times for each height on the skull prototype, the motion of impact of the Takraw ball and the materials have been recorded by High Speed Camera. The result below from table 4.9 show the velocity after impact of composite material and a condition without using any test material according to height.

Table 4.8: Velocity after impact Experiment 2

Velocity After Impact (m/s)		
Height	**w/o Headband**	**w Headband (Composite material)**
0.7	1.9250	1.9149
1.2	2.5202	2.5196
1.7	3.1027	3.0992
2.2	3.4827	3.4645

For the velocity after impact, the quality characteristic of composite material should be produce a same or close value from the benchmark velocity after impact value which produce by a condition without using any test materials. This is because it means the composite material is reducing the force from the ball but does not change the velocity of the ball after impact whether improve or reduce the performance of the Takraw player.

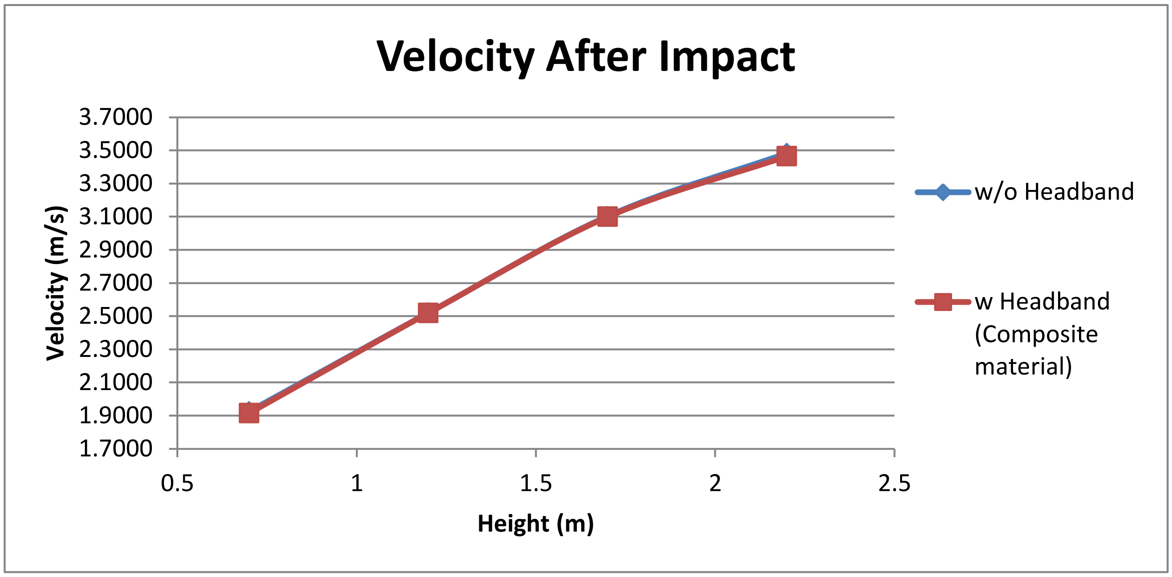

Figure 4.7: Velocity after impact graph Experiment 2

From the graph in figure 4.7 it shows that, the pattern and the value of velocity after impact of composite material and a condition without using test material are almost the same. But the exact value of velocity after impact produce by the composite material was different and slightly lower which is 3.46 m/s compared to the benchmark value which is 3.48 m/s.

This shown the result from the experiment 1 was accepted even the material was tested on the skull prototype which make the composite material choosen as the best material in term of velocity after impact because it produce a lower value than the benchmark value and it means it reduce the impact force from the ball but not effecting the performance of the Takraw player whether by improve or reducing their performance.

The result below from table 4.10 show the ball deformation of composite materials and a condition without using any test material as a benchmark value.

Table 4.9: Ball deformation Experiment 2

	Ball Deformation (m)	
Height	**w/o Headband**	**w Headband (Composite material)**
0.7	0.0047	0.0063
1.2	0.0066	0.0088
1.7	0.0085	0.0101
2.2	0.0104	0.0104

The quality characteristics of composite material that is needed in term of ball deformation is the material should be producing a low value or near with the benchmark value of ball deformation produce by a condition without using any test materials. This is because, from the equation F = kx, the higher the deformation occur, the lower the force produce as there is energy loss during the ball deformation. When the force reduced, this prevents the player from having severe injury due to the head impact during heading without affecting the performance of player.

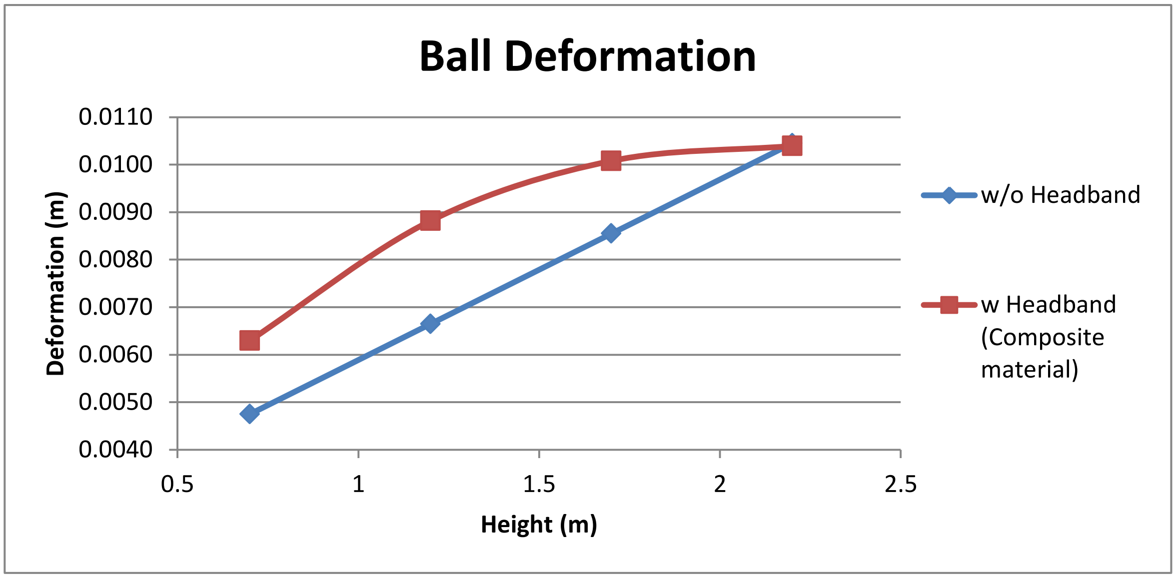

Figure 4.8: Ball deformation graph Experiment 2

From the graph in figure 4.8 it shows that, composite material produce higher value of ball deformation compared to the benchmark value at the beginning of the graph which at height 0.7 m and 1.2 m. But starting at height 1.7 m, the composite material starting to produce a linear graph pattern and finally producing a same value of ball deformation as a condition without using any test material at height 2.2 m which is 0.0104 m.

This shows the result from the experiment 1 was accepted even the material was tested on the skull prototype which make the composite material chosen as the best material in term of ball deformation because it produce a same value as the benchmark value and it means that even it does reduce the force of the Takraw ball but it do not reduce the velocity of the Takraw ball too much which can affect the performance of the Takraw player.

The result below from table 4.11 show the contact time of composite materials and a condition without using any test material as a benchmark value.

Table 4.10: Contact time Experiment 2

Contact Time (s)		
Height	**w/o Headband**	**w Headband (Composite material)**
0.7	0.0100	0.0125
1.2	0.0100	0.0125
1.7	0.0100	0.0125
2.2	0.0092	0.0125

The quality characteristics of the composite material that is needed in term of contact time is the material should be producing a higher value than the benchmark value produce by a condition without using any test materials. This is because, according to equation F = ma, it means that, the higher contact time produce by the material, the lower the force exerted. This is because the ΔT from the acceleration, $a = \Delta V / \Delta T$ is inversely proportional to the force.

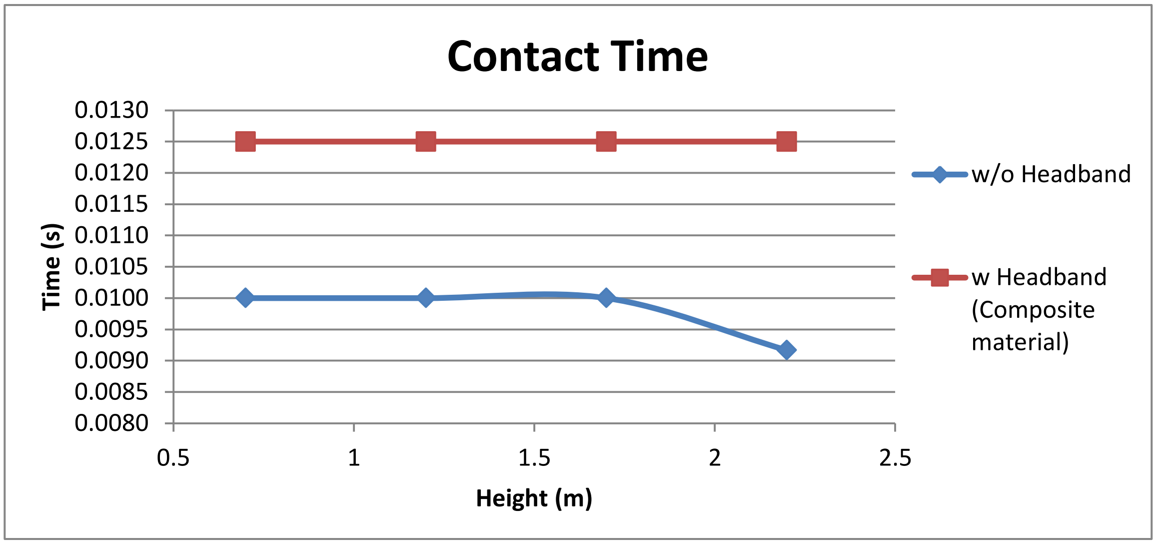

Figure 4.9: Contact time graph Experiment 2

From the graph showed in figure 4.9, the pattern of the graph is quite same and the contact time produces by composite material is higher than a benchmark value by a condition without the test material which is 0.0125 s and followed by the benchmark value is 0.092 s at height 2.4 m.

This result proves the result from experiment 1 that the composite material is the best material in term of contact time because it produce a higher contact time value than a condition without using test material and the composite material produce high contact time will be produce lower force exerted from equation F = ma.

The result below from table 4.12, it show the coefficient of restitution of composite materials and a condition without using any test material as a benchmark value.

Table 4.11: Coefficient of restitution Experiment 2

	Coefficient of Restitution	
Height	**w/o Headband**	**w Headband (Composite material)**
0.7	0.6847	0.6847
1.2	0.6958	0.7043
1.7	0.7313	0.7344
2.2	0.7453	0.7432

The quality characteristics of the composite material that is needed in term of coefficient of restitution is that composite material should have a same value or close to the benchmark value produce by a condition without using test materials. This is because, the characteristic that needed for the composite material is same as the benchmark value so that it does not change the performance of the Takraw player whether elastic or inelastic characteristic which maybe can affect improve or reduce their performance.

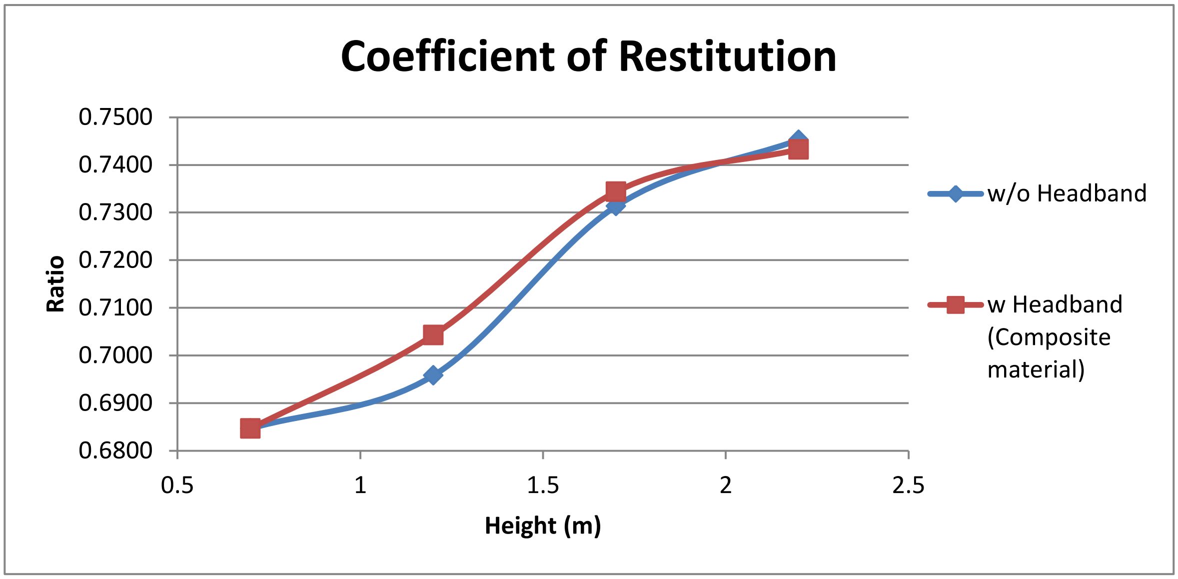

Figure 4.10: Coefficient of restitution graph Experiment 2

From the graph in figure 4.10 it shows that, the graph pattern produces by both composite material and a condition without using test material is quite the same. The benchmark value at height 2.4 m is 0.7453 and the composite material produce a value 0.7432.

This proves the result from experiment 1 composite material chosen as the best material in term of coefficient of restitution because it has the characteristic that quite the same as a condition without using test material which act as a benchmark value thus reducing the possibility of the composite material will affect the performance of the Takraw player during a game.

Table 4.12: Experiment 2 conclusion

Parameter	Observation
Velocity after impact	Composite material produce lower but slightly close value than without headband
Ball deformation	Composite material produce same value to without headband at height 2.2 m
Contact time	Composite material produce higher value than without headband
Coefficient of restitution	Composite material produce lower but slightly close value than without headband
Brain Acceleration	Composite material produce lower value than without headband

Based on data recorded, composite material satisfy each parameter and prove the result from experiment 1 as shown in table 4.14. Because of that, composite material prove and chosen as the best material for padded bandana for Takraw player. Based on the result collected, the composite material was choosen to be as a material of new padded bandana in the development of padded bandana for Takraw players.

4.4 Equation involve in calculation

All the raw data collected from the impact motion of Takraw ball with test materials by high speed camera was in unit pixel (px). For the data collected from the Force plate and Accelerometer, the raw data collected can be obtained by using Microsoft Excel and the maximum peak of force and brain acceleration can be calculated for each height.

4.4.1 To find Velocity after impact (m/s)

In order to get the value of velocity after impact of each materials, the raw data recorded were analyzed in order to get the diameter and distance of the ball in 10 frames after impact and the following equation need to be used:

Measured Takraw ball diameter (D_b *m*) = 0.1359 *m*

Takraw ball diameter in pixel (D_b *px*) = ________ *px*

Ball distance in 10 frame after impact (*B*-*A* *px*) = _________ *px*

$$\frac{(\boldsymbol{B-A})\boldsymbol{px}}{(\boldsymbol{Db})\ \boldsymbol{px}} \times (\boldsymbol{Db})\boldsymbol{m} = \boldsymbol{meter}\ (\boldsymbol{m})$$

$$\frac{\boldsymbol{meter}\ (\boldsymbol{m})}{\boldsymbol{Frame\ per\ second}\ (\boldsymbol{fr/s})} = \boldsymbol{Velocity}\ (\boldsymbol{m/s})$$

Example: Condition: No headband, at height 2.4 meters, 400 frame/second

Measured Takraw ball diameter (D_b *m*) = 0.1359 *m*

Takraw ball diameter in pixel (D_b *px*) = 81.4 *px*

Ball distance in 10 frame after impact (*B-A px*) = 2.7 *px*

$$\frac{(\mathbf{2.7})\boldsymbol{px}}{(\mathbf{81.4})\ \boldsymbol{px}} \times (\mathbf{0.1359})\boldsymbol{m} = \mathbf{4.5} \times \mathbf{10^{-3}}\ (\boldsymbol{m})$$

$$\frac{\mathbf{4.5} \times \mathbf{10^{-3}}\ (\boldsymbol{m})}{\mathbf{1/400}\ (\boldsymbol{fr/s})} = \mathbf{1.8}\ (\boldsymbol{m/s})$$

4.4.2 To find Ball deformation (m)

To get the value of ball deformation, the first thing to get done is to analyz the intial size and the final size of the ball during the deformation in pixel.

$$\boldsymbol{Initial\ size - Final\ size = Deformation(px)}$$

After that, in order to convert from pixel to meter, the following equation was used:

$$\frac{\boldsymbol{Db\ (m)}}{\boldsymbol{Db\ (px)}} \times \boldsymbol{Deformation\ (px) = meter\ (m)}$$

Example: Condition: No headband, at height 2.4 meters

Measured Takraw ball diameter ($D_b\, m$) = 0.1359 *m*

Takraw ball diameter in pixel ($D_b\, px$) = 81.4 *px*

$$\mathbf{82\ (px) - 74(px) = 8(px)}$$

$$\frac{\mathbf{0.1359\ (m)}}{\mathbf{81.4\ (px)}} \times \mathbf{8\ (px) = 0.0134\ (m)}$$

4.4.3 To find Contact time (s)

The contact time of the ball and the material can be obtained by analyzed the motion of impact by using high speed camera starting from the frame where the ball start to touch material until the last frame where the ball touch the material.

4.4.4 To find Coefficient of restitution

The coefficient of restitution of each material can be obtained by dividing the velocity after impact and velocity before impact of the ball with material by using the following equation:

$$\boldsymbol{e = \frac{Vba\ (px)}{Vab\ (px)}}$$

Example: Condition: No headband, at height 2.4 meters

Velocity after impact in pixel (*Vba px*) = 1.2 *px*

Velocity before impact in pixel (*Vab px*) = 1.9 *px*

$$\boldsymbol{e = \frac{1.2\ (px)}{1.9\ (px)} = 0.63}$$

4.5 Development of Padded Bandana

The new padded bandana that has been made is lightweight and adjustable with an impact absorbing composite material layer that wraps around the head, offering increased protection at crucial impact zones where many head impacts tend to occur. The padded bandana is design based on an idea came from the journal Hirsch et al. (2001) as shown in figure 4.12 that invent a bandana head protector using fabric and closed cell foam to reduce head injuries among soccer players. The padded bandana design was improved from the original idea according to the purpose of the bandana in this study which is for the Sepak Takraw player. Thus, a new design of bandana that can aid the Takraw player during a game was proposed.

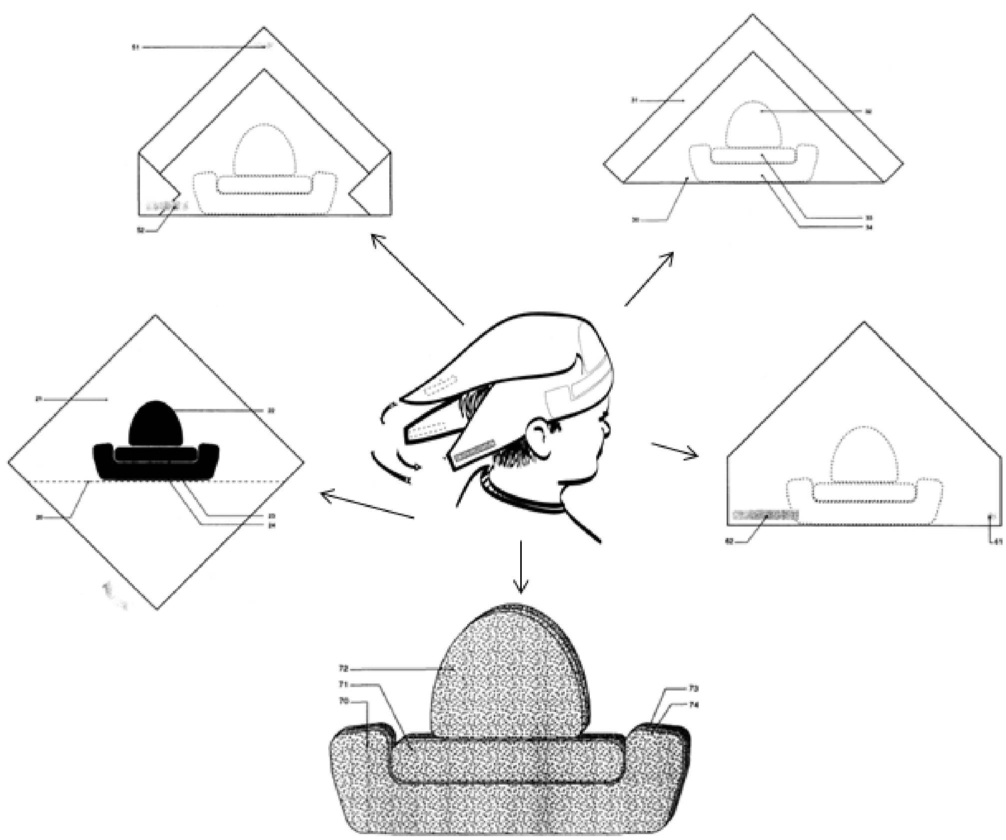

Figure 4.11: Drawing of bandana from Hirsch et al. (2001)

The new padded bandana was designed not just to keeping with the spirit of the game, but also the rules of Sepak Takraw. This is because, based on the experiment result in Experiment 1 and Experiment 2, the first thing to be consider in the expected result of velocity after impact produce by the material should not exceed the benchmark value of velocity after impact by a condition without test material. So that, the new padded bandana is in compliance with International Sepak Takraw Federation (ISTAF, 2007) rules and regulation. The internal design of new padded bandana was shown in figure 4.13.

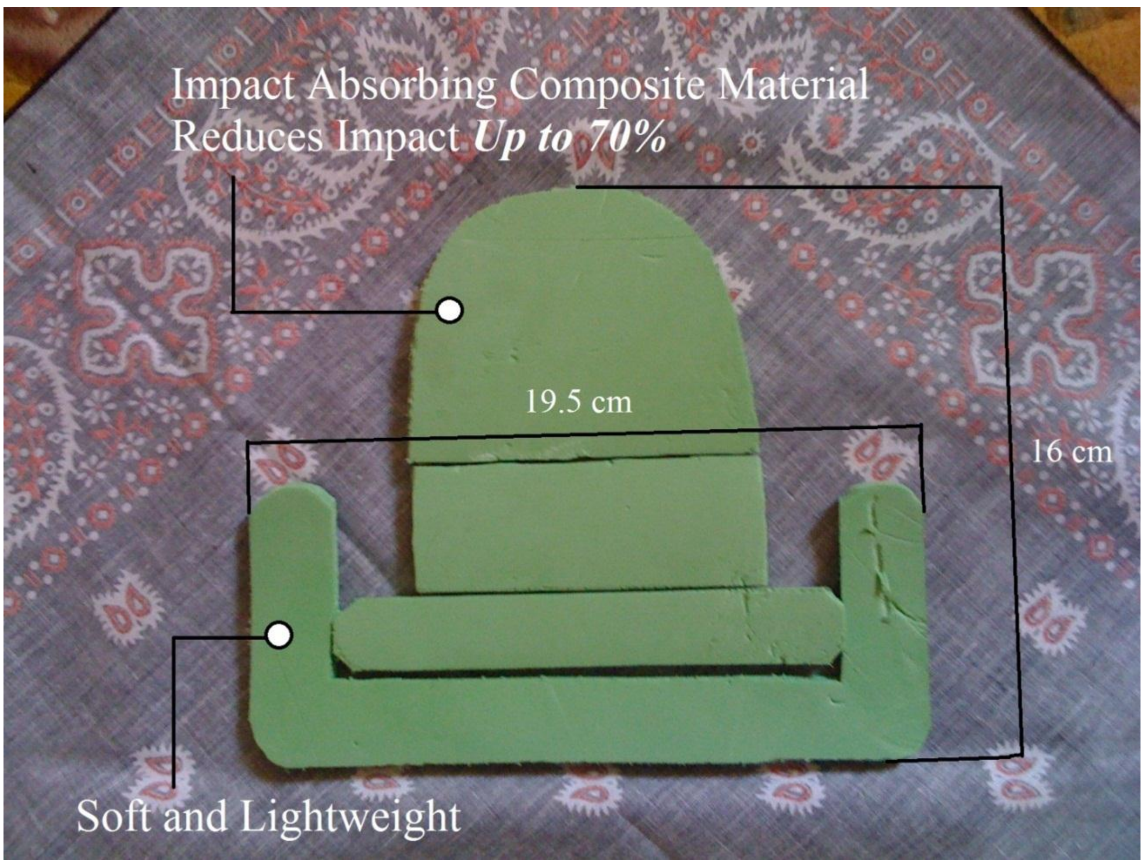

Figure 4.12: Internal design of new padded bandana

Figure 4.13: Side and front view of new padded bandana worn by Takraw player

The features of padded bandana:

1. The bandana reduces the risk of head injury when exposed to external force.
2. The bandana absorbs perspiration as the material of bandana is cotton.
3. The composite material of bandana covers from forehead until top of the head.
4. The bandana can be placed inside protective helmets for other sports purposes such as bicycle and motorcycle helmet and batter's helmet. This will significantly reduce the risk of having a head injury.
5. The primary purposes of the protective bandana for Sepak Takraw player and also can be used for children's recreational play.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In this chapter, a conclusion has been made by summaries all part of this paper study and recommendation in future in order to improve the knowledge obtained from this study will also be explained. By referring the conclusion made in this study, it is related to the initial objectives targeted. Besides that, by referring with the recommendation to this study, scopes and limitation of this study can be improve and enriched in future.

5.2 CONCLUSIONS

In conclusion, the objective to identify the most suitable material of bandana that can protect the head of player and to fabricate a bandana which consists of the most suitable material that can be part of the bandana and protect the head of the player was met. Result from Experiment 1 show that among the 3 test material, composite material was the most suitable material to be part of the bandana in order to protect the head of Takraw player during a game. This is proven in the Experiment 2 which the composite material was tested on the skull prototype as a representative head of Takraw player in a real situation.

The result and data that has been used in this study can be useful for any research. Since an engineering study about Sepak Takraw still few and developing, this study can be used as base standard information for future reference for others interested in this kind of motion of impact, study of material properties and the study of development of padded bandana in Takraw sports.

5.3 RECOMMENDATION

Since the maximum level of height that has been set up in Experiment 1 is 2.4 meters and in Experiment 2 is 2.2 meters, for future study, researcher needs to find a suitable place or laboratory for conducting an experiment that can fulfill the requirement of study which has a higher maximum level of height indoor laboratory. This would allow the velocity that can be produce from the drop ball can be same as the real situation in a Sepak Takraw game. Other than that, having an automatic ball feeder is another solution for the velocity of the Takraw ball is not the same as the velocity of the Takraw ball in a game. This is because an automatic ball feeder can set the velocity of the ball and also the angle of the Takraw ball launch to the experiment test subject. The last recommendation that need to be considered is to test more material so that there is more than one source of material that can be used as part of development of padded bandana for takraw players.

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APPENDIX A

HIGH SPEED CAMERA ANALYSIS

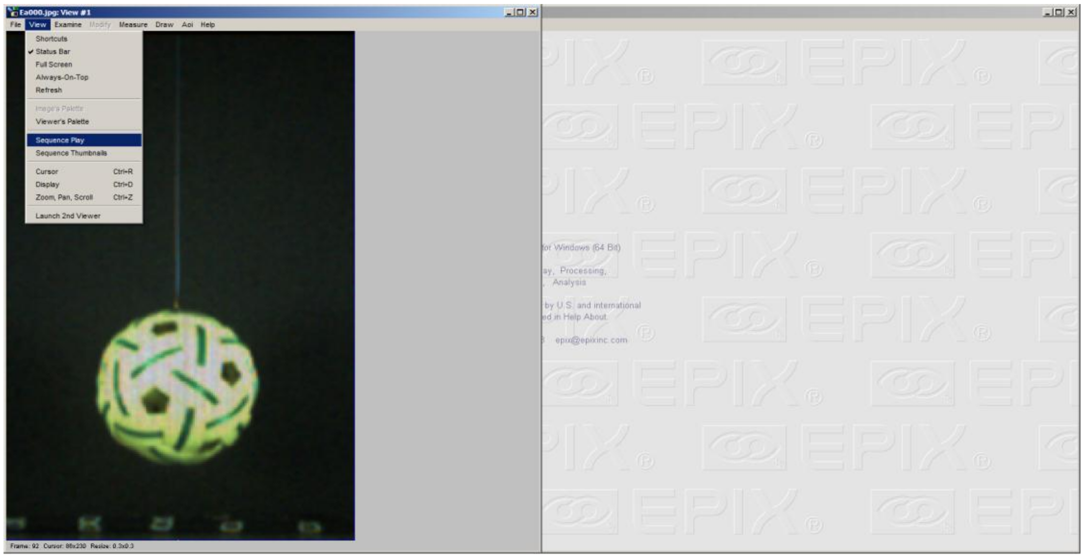


Figure A-1: Select Sequence Play to play the image sequence

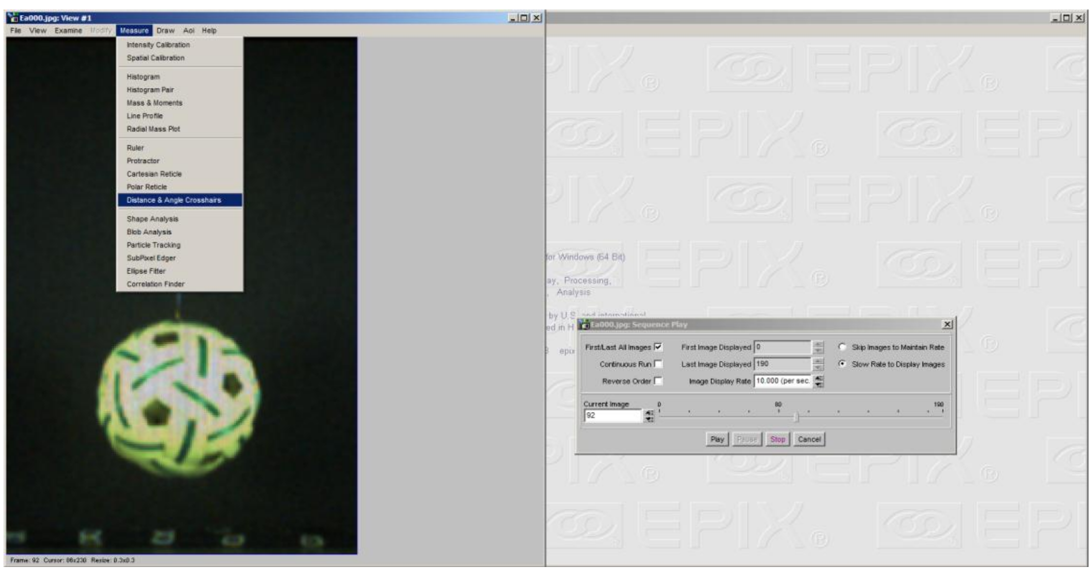


Figure A-2: Select Distance & Angle Crosshair to measure the distance between origin and point 1

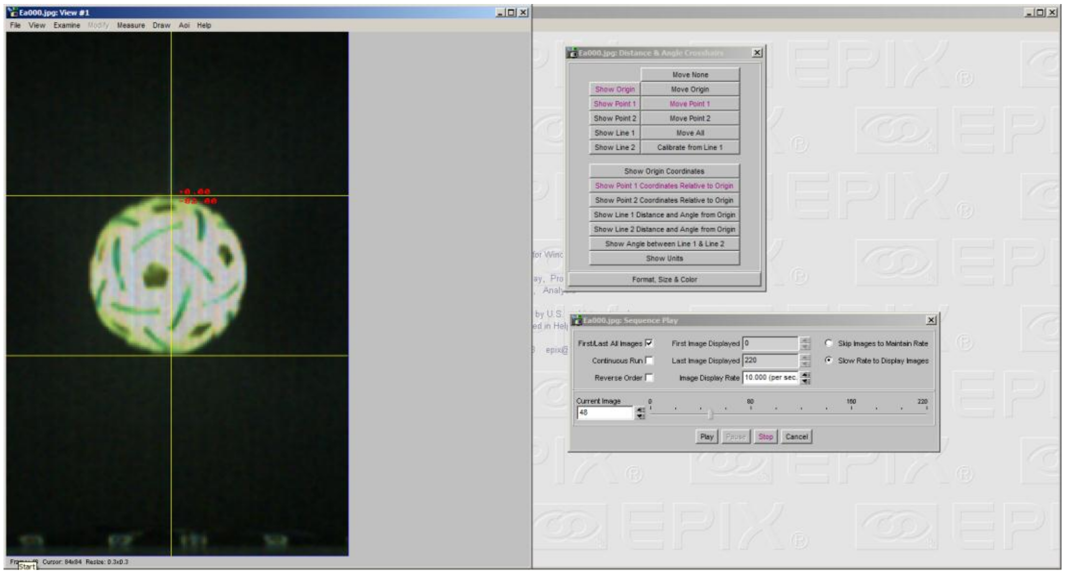


Figure A-3: Measure the ball diameter using origin and point 1

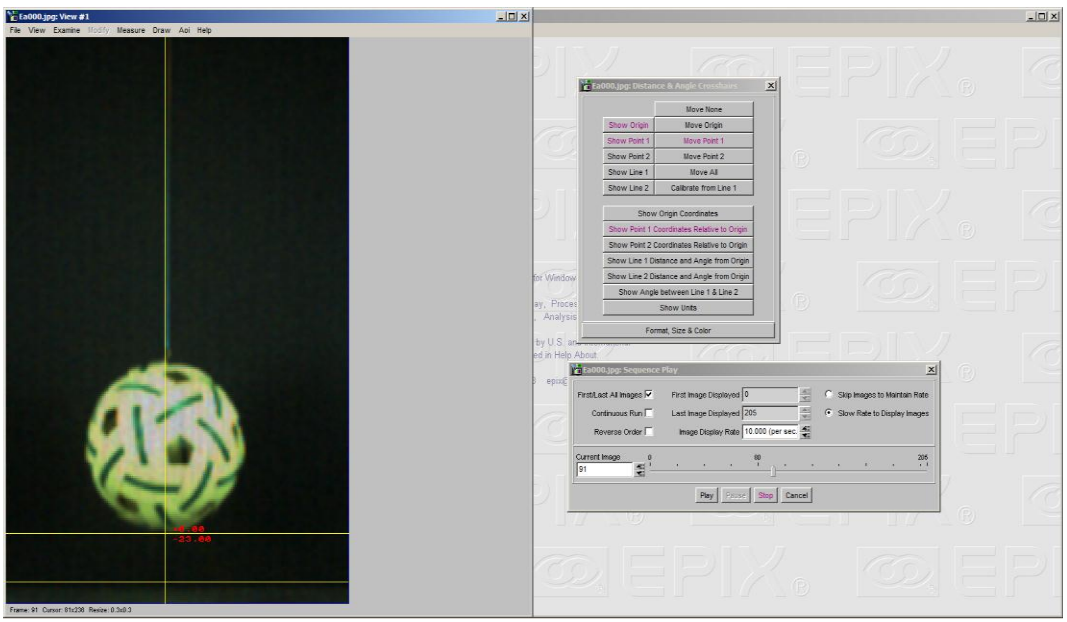


Figure A-4: Measure the velocity after impact without bandana

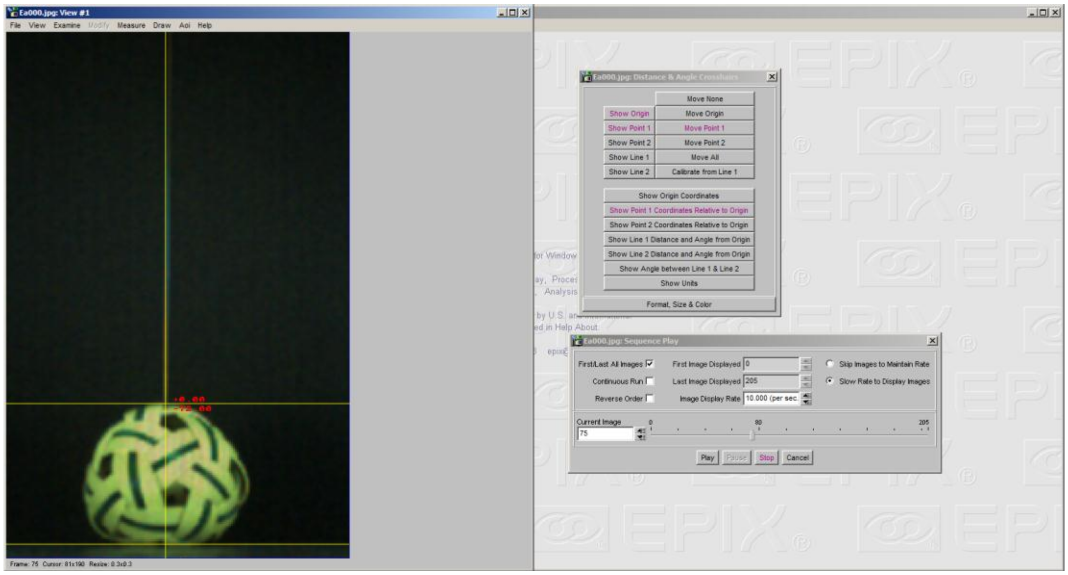


Figure A-5: Measure ball deformation without bandana

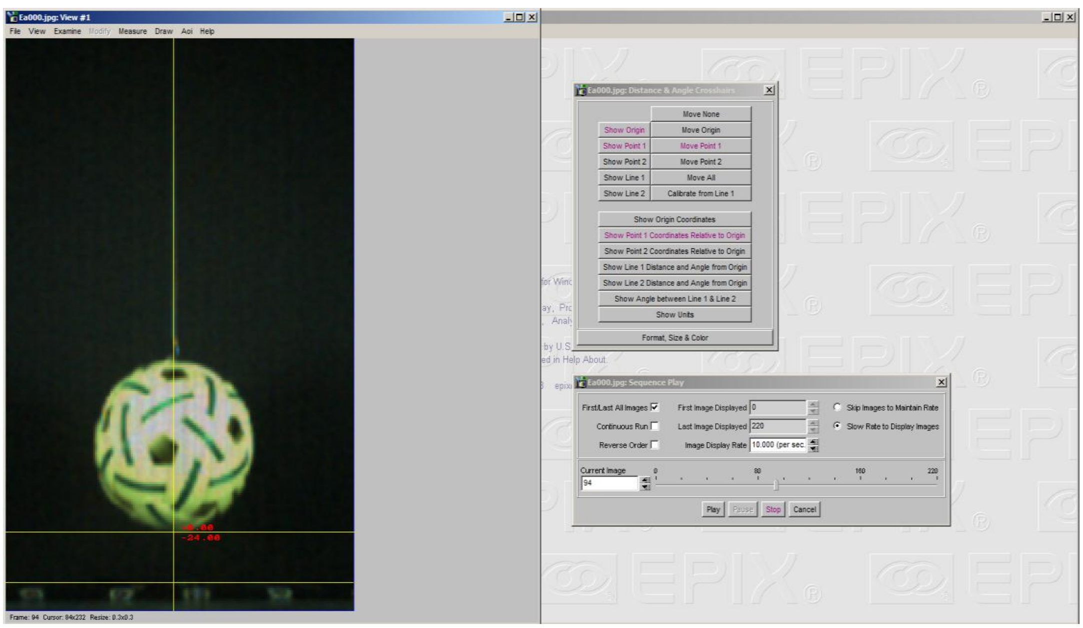


Figure A-6: Measure velocity after impact of the material

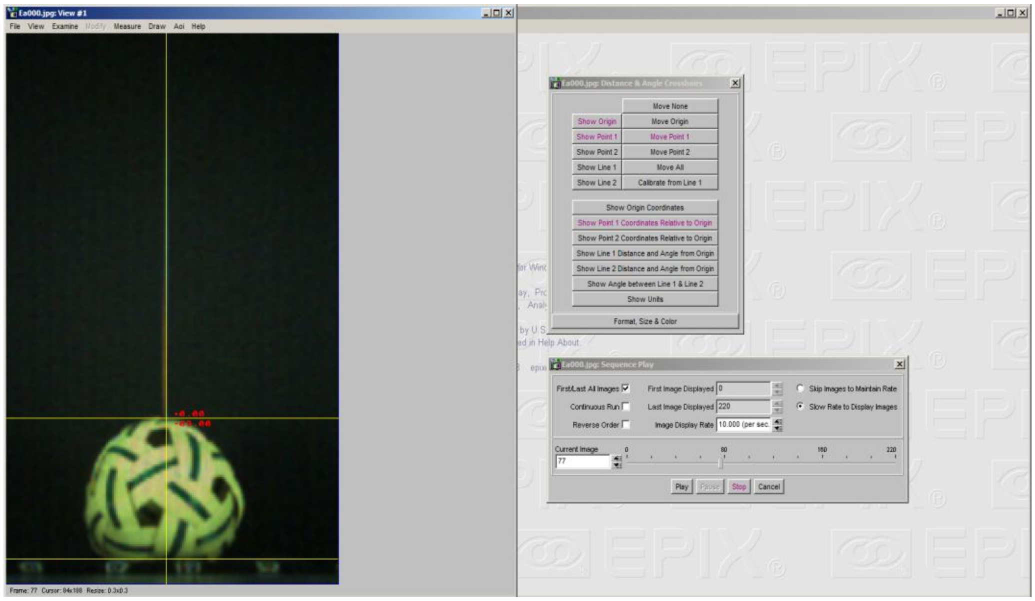


Figure A-7: Measure ball deformation of the material

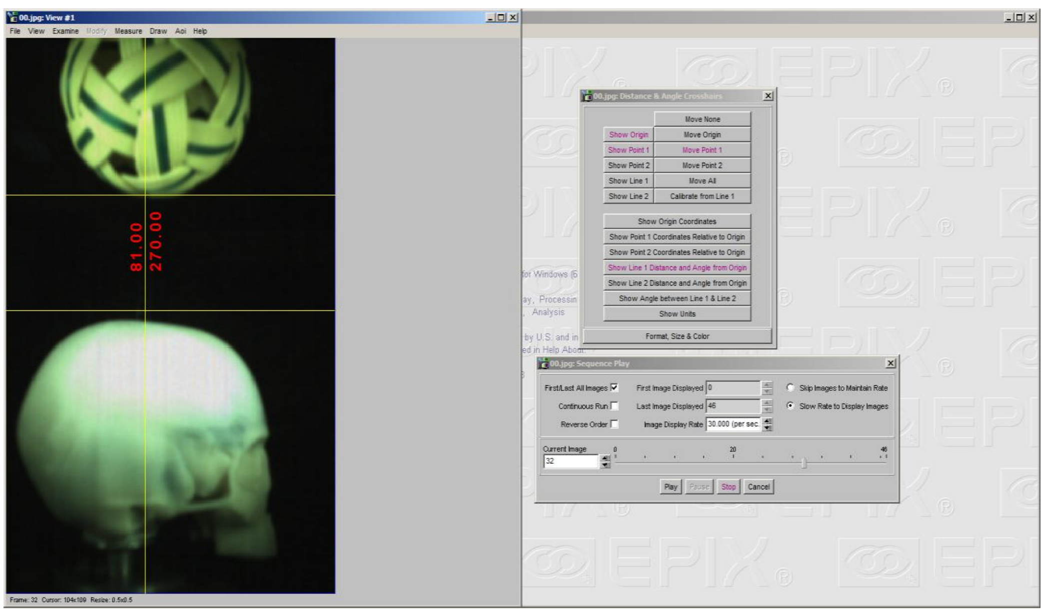


Figure A-8: Measure velocity after impact without bandana on skull prototype

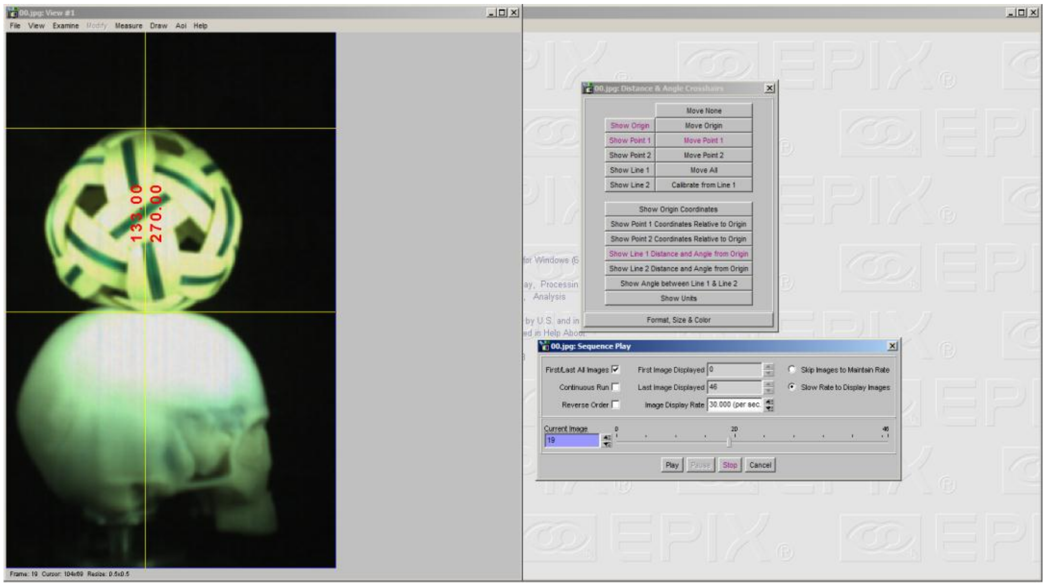


Figure A-9: Measure ball deformation without bandana on skull prototype

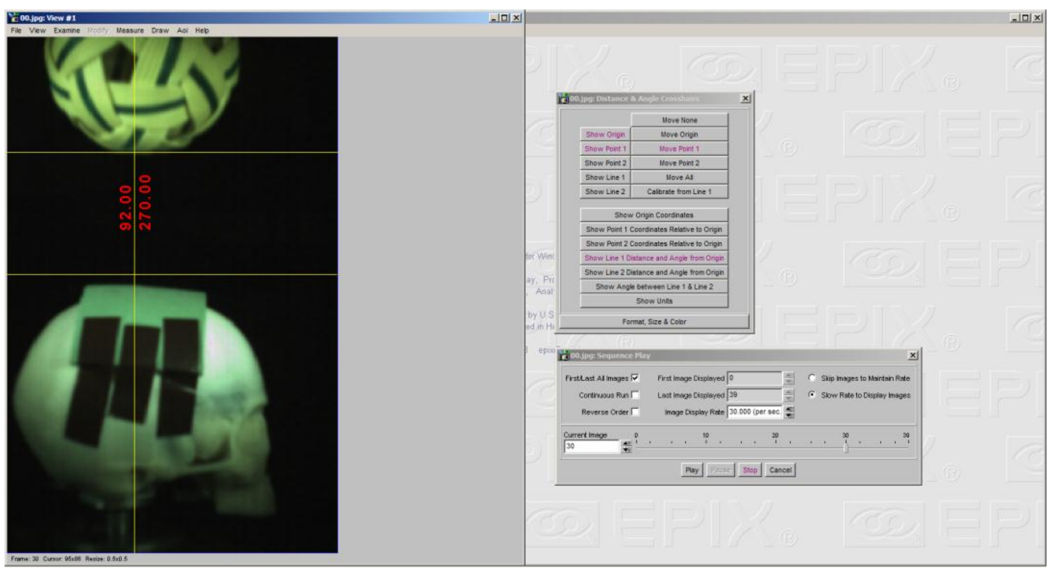


Figure A-10: Measure velocity after impact of material on skull prototype

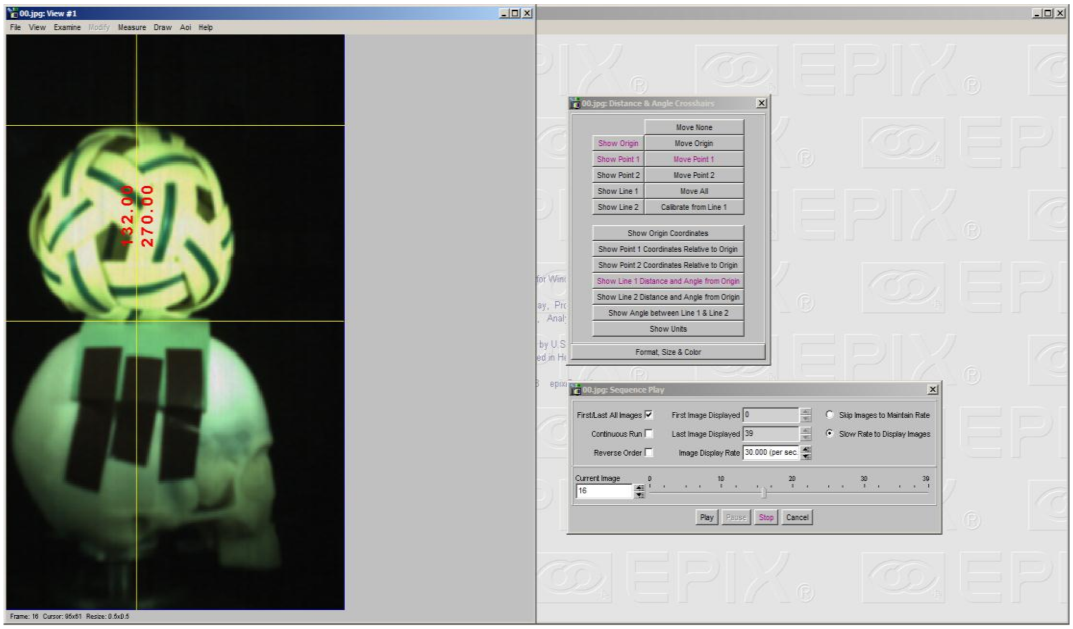
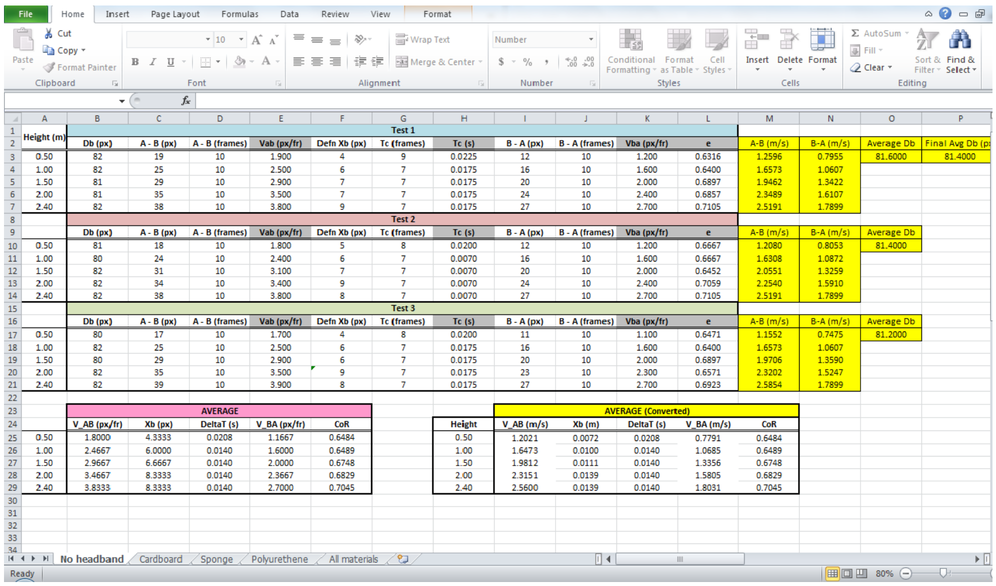


Figure A-11: Measure ball deformation of material on skull prototype

APPENDIX B

HIGH SPEED CAMERA ANALYSIS RESULT

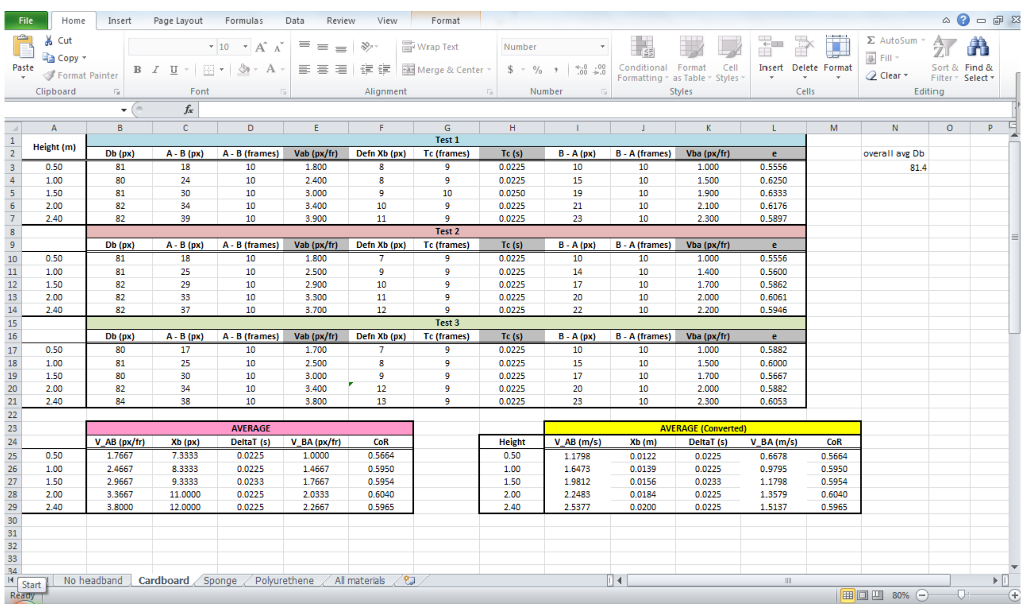


Height (m)	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e	A-B (m/s)	B-A (m/s)	Average Db	Final Avg Db (px
	Test 1														
0.50	82	19	10	1.900	4	9	0.0225	12	10	1.200	0.6316	1.2596	0.7955	81.6000	81.4000
1.00	82	25	10	2.500	6	7	0.0175	16	10	1.600	0.6400	1.6573	1.0607		
1.50	81	29	10	2.900	7	7	0.0175	20	10	2.000	0.6897	1.9462	1.3422		
2.00	81	35	10	3.500	7	7	0.0175	24	10	2.400	0.6857	2.3489	1.6107		
2.40	82	38	10	3.800	9	7	0.0175	27	10	2.700	0.7105	2.5191	1.7899		
	Test 2														
	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e	A-B (m/s)	B-A (m/s)	Average Db	
0.50	81	18	10	1.800	5	8	0.0200	12	10	1.200	0.6667	1.2080	0.8053	81.4000	
1.00	80	24	10	2.400	6	7	0.0070	16	10	1.600	0.6667	1.6308	1.0872		
1.50	82	31	10	3.100	7	7	0.0070	20	10	2.000	0.6452	2.0551	1.3259		
2.00	82	34	10	3.400	9	7	0.0070	24	10	2.400	0.7059	2.2540	1.5910		
2.40	82	38	10	3.800	8	7	0.0070	27	10	2.700	0.7105	2.5191	1.7899		
	Test 3														
	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e	A-B (m/s)	B-A (m/s)	Average Db	
0.50	80	17	10	1.700	4	8	0.0200	11	10	1.100	0.6471	1.1552	0.7475	81.2000	
1.00	82	25	10	2.500	6	7	0.0175	16	10	1.600	0.6400	1.6573	1.0607		
1.50	80	29	10	2.900	6	7	0.0175	20	10	2.000	0.6897	1.9706	1.3590		
2.00	82	35	10	3.500	9	7	0.0175	23	10	2.300	0.6571	2.3202	1.5247		
2.40	82	39	10	3.900	8	7	0.0175	27	10	2.700	0.6923	2.5854	1.7899		

	AVERAGE				
	V_AB (px/fr)	Xb (px)	DeltaT (s)	V_BA (px/fr)	CoR
0.50	1.8000	4.3333	0.0208	1.1667	0.6484
1.00	2.4667	6.0000	0.0140	1.6000	0.6489
1.50	2.9667	6.6667	0.0140	2.0000	0.6748
2.00	3.4667	8.3333	0.0140	2.3667	0.6829
2.40	3.8333	8.3333	0.0140	2.7000	0.7045

	AVERAGE (Converted)				
Height	V_AB (m/s)	Xb (m)	DeltaT (s)	V_BA (m/s)	CoR
0.50	1.2021	0.0072	0.0208	0.7791	0.6484
1.00	1.6473	0.0100	0.0140	1.0685	0.6489
1.50	1.9812	0.0111	0.0140	1.3356	0.6748
2.00	2.3151	0.0139	0.0140	1.5805	0.6829
2.40	2.5600	0.0139	0.0140	1.8031	0.7045

Figure B-1: Result analysis without bandana



Height (m)	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e		overall avg Db
	Test 1												
0.50	81	18	10	1.800	8	9	0.0225	10	10	1.000	0.5556		81.4
1.00	80	24	10	2.400	8	9	0.0225	15	10	1.500	0.6250		
1.50	81	30	10	3.000	9	10	0.0250	19	10	1.900	0.6333		
2.00	82	34	10	3.400	10	9	0.0225	21	10	2.100	0.6176		
2.40	82	39	10	3.900	11	9	0.0225	23	10	2.300	0.5897		
	Test 2												
	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e		
0.50	81	18	10	1.800	7	9	0.0225	10	10	1.000	0.5556		
1.00	81	25	10	2.500	9	9	0.0225	14	10	1.400	0.5600		
1.50	82	29	10	2.900	10	9	0.0225	17	10	1.700	0.5862		
2.00	82	33	10	3.300	11	9	0.0225	20	10	2.000	0.6061		
2.40	82	37	10	3.700	12	9	0.0225	22	10	2.200	0.5946		
	Test 3												
	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e		
0.50	80	17	10	1.700	7	9	0.0225	10	10	1.000	0.5882		
1.00	81	25	10	2.500	8	9	0.0225	15	10	1.500	0.6000		
1.50	80	30	10	3.000	9	9	0.0225	17	10	1.700	0.5667		
2.00	82	34	10	3.400	12	9	0.0225	20	10	2.000	0.5882		
2.40	84	38	10	3.800	13	9	0.0225	23	10	2.300	0.6053		

	AVERAGE				
	V_AB (px/fr)	Xb (px)	DeltaT (s)	V_BA (px/fr)	CoR
0.50	1.7667	7.3333	0.0225	1.0000	0.5664
1.00	2.4667	8.3333	0.0225	1.4667	0.5950
1.50	2.9667	9.3333	0.0233	1.7667	0.5954
2.00	3.3667	11.0000	0.0225	2.0333	0.6040
2.40	3.8000	12.0000	0.0225	2.2667	0.5965

	AVERAGE (Converted)				
Height	V_AB (m/s)	Xb (m)	DeltaT (s)	V_BA (m/s)	CoR
0.50	1.1798	0.0122	0.0225	0.6678	0.5664
1.00	1.6473	0.0139	0.0225	0.9795	0.5950
1.50	1.9812	0.0156	0.0233	1.1798	0.5954
2.00	2.2483	0.0184	0.0225	1.3579	0.6040
2.40	2.5377	0.0200	0.0225	1.5137	0.5965

Figure B-2: Result analysis with bandana

Height (m)	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e
	Test 1										
0.70	142	74	10	7.400	6	4	0.0100	49	10	4.900	0.6622
1.20	143	95	10	9.500	7	4	0.0100	66	10	6.600	0.6947
1.70	143	111	10	11.100	9	4	0.0100	81	10	8.100	0.7297
2.20	143	124	10	12.400	9	4	0.0100	92	10	9.200	0.7419
	Test 2										
	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e
0.70	143	74	10	7.400	4	4	0.0100	51	10	5.100	0.6892
1.20	144	96	10	9.600	7	4	0.0100	67	10	6.700	0.6979
1.70	142	112	10	11.200	9	4	0.0100	82	10	8.200	0.7321
2.20	143	123	10	12.300	12	3	0.0075	92	10	9.200	0.7480
	Test 3										
	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e
0.70	144	74	10	7.400	5	4	0.0100	52	10	5.200	0.7027
1.20	143	95	10	9.500	7	4	0.0100	66	10	6.600	0.6947
1.70	143	112	10	11.200	9	4	0.0100	82	10	8.200	0.7321
2.20	144	122	10	12.200	12	4	0.0100	91	10	9.100	0.7459

Height	Average Db (px)	Overall Db Average (px)
0.7	143.0000	143.0833
1.2	143.3333	
1.7	142.6667	
2.2	143.3333	

	AVERAGE				
Height	V_AB (px/fr)	Xb (px)	DeltaT (s)	V_BA (px/fr)	CoR
0.70	7.4000	5.0000	0.0100	5.0667	0.6847
1.20	9.5333	7.0000	0.0100	6.6333	0.6958
1.70	11.1667	9.0000	0.0100	8.1667	0.7313
2.20	12.3000	11.0000	0.0092	9.1667	0.7453

	AVERAGE (converted)				
Height	V_AB (m/s)	Xb (m)	DeltaT (s)	V_BA (m/s)	CoR
0.7	2.8115	0.0047	0.0100	1.9250	0.6847
1.2	3.6220	0.0066	0.0100	2.5202	0.6958
1.7	4.2425	0.0085	0.0100	3.1027	0.7313
2.2	4.6731	0.0104	0.0092	3.4827	0.7453

Figure B-3: Result analysis without bandana on the skull prototype

Height (m)	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e
	Test 1										
0.70	145	74	10	7.400	8	5	0.0125	49	10	4.900	0.6622
1.20	143	94	10	9.400	10	5	0.0125	66	10	6.600	0.7021
1.70	143	112	10	11.200	11	5	0.0125	81	10	8.100	0.7232
2.20	144	124	10	12.400	11	5	0.0125	92	10	9.200	0.7419
	Test 2										
	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e
0.70	143	74	10	7.400	6	5	0.0125	51	10	5.100	0.6892
1.20	144	94	10	9.400	10	5	0.0125	67	10	6.700	0.7128
1.70	145	112	10	11.200	11	5	0.0125	82	10	8.200	0.7321
2.20	143	123	10	12.300	11	5	0.0125	92	10	9.200	0.7480
	Test 3										
	Db (px)	A - B (px)	A - B (frames)	Vab (px/fr)	Defn Xb (px)	Tc (frames)	Tc (s)	B - A (px)	B - A (frames)	Vba (px/fr)	e
0.70	144	74	10	7.400	6	5	0.0125	52	10	5.200	0.7027
1.20	144	96	10	9.600	8	5	0.0125	67	10	6.700	0.6979
1.70	144	111	10	11.100	10	5	0.0125	83	10	8.300	0.7477
2.20	144	123	10	12.300	11	5	0.0125	91	10	9.100	0.7398

Height (m)	Average Db (px)	Overall Average Db (px)
0.7	144.0000	143.8333
1.2	143.6667	
1.7	144.0000	
2.2	143.6667	

	AVERAGE				
Height (m)	V_AB (px/fr)	Xb (px)	DeltaT (s)	V_BA (px/fr)	CoR
0.70	7.4000	6.6667	0.0125	5.0667	0.6847
1.20	9.4667	9.3333	0.0125	6.6667	0.7043
1.70	11.1667	10.6667	0.0125	8.2000	0.7344
2.20	12.3333	11.0000	0.0125	9.1667	0.7432

	AVERAGE (Converted)				
Height (m)	V_AB (m/s)	Xb (m)	DeltaT (s)	V_BA (m/s)	CoR
0.7	2.7968	0.0063	0.0125	1.9149	0.6847
1.2	3.5779	0.0088	0.0125	2.5196	0.7043
1.7	4.2204	0.0101	0.0125	3.0992	0.7344
2.2	4.6613	0.0104	0.0125	3.4645	0.7432

Figure B-4: Result analysis with bandana on the skull prototype