John Johnson

EXERCISE TECHNIQUE MANUAL FOR RESISTANCE TRAINING BY USING BODY WEIGHT

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Satakunnan ammattikorkeakoulu
Satakunta University of Applied Sciences

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John Johnson
Satakunta University of Applied Sciences
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The purpose of this thesis was to create an exercise technique manual from a product I designed in the field of health promotion. According to Ewles & Simnett (1995, 20) health promotion aims to empower people to have more control over aspects of their lives which affects their health. This is in line with the Website of World Health Organization (2014) who identified that health promotion was a way of equipping people to have more power enabling them to make choices in regards to improving their well-being.

The manual was designed for people whom are interested in purchasing the product. The manual focuses on the practical use of the product which can be seen through photos of the exercises being performed. It then identifies the benefits each exercise has on the muscle area. This includes the primary muscles targeting (single-joint or multijoint), the contraindications of the exercise, the starting position, notes concerning the exercise being performed, hand grip position and the recommended number of repetitions and sets to be performed.

The theoretical framework of the thesis incorporates some of the positive benefits resistance training can have for example on bone health. It examines different muscle contractions that can enhance performance using this piece of equipment. It briefly discusses the biomechanics involved in the exercises focusing on torque force. Lastly the theory looks at the origins of the design, focusing on the design process the intended purpose of the project for example what demographic the design is aimed at; lastly there is a description of the device and its operation.

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CONTENTS

1 INTRODUCTION

Since the age of eight I had been involved in team sports that emphasized being physically fit. I played Rugby league in winter and cricket for my school in the summer. Whilst cricket didn't involve much health promotion rugby league did. It involved training twice a week one session was dedicated to physical fitness and one session dedicated to drills, tactics used for the game, then on the weekend we would play a game for sixty minutes of stop start sprinting and a lot of physicality. When I reached my mid teens a large number of players started going to the gym to gain muscle mass. I didn't however; I wanted to have more strength. So I decided to buy a home gym compromising of bench press, dumbbells, leg curls and incorporated the home gym with using my own body weight exercises.

I was now training four times a week and playing twice a week. Two training sessions for school and two for my club, these training sessions involved an assortment of plyometrics and resistance training. I would continue playing competitive rugby league until I was twenty-seven, and remained physically active by attending a gym four times a week. This lasted till my second child was born hence the reason I had come up with the idea for my product which saved money in the long run on expensive gym membership. Instead of judging myself by how much weight I could lift doing bench press, or arm curls, I found the real strength came from my own bodyweight, not only does this equipment build strength it incorporates cardio at the same time. This left me more fatigued at the end of a session than a gym did. I found this more beneficial for real life situations; this is discussed further in the design process. I feel more control over my movements which can leave me less vulnerable to injuries for example I received a rotator cuff injury from performing repetitive overhead dumbbell movements.

Literature on the topic of resistance training is extensive, covering numerous and diverse perspectives on the changing nature of resistance training. This theoretical component does not exhaust the benefits of resistance training; however it does aim to identify key components of how resistance training enhances one's health and well being. Most importantly it is hoped this component shows the value the product has in health promotion.

2 BENEFITS OF RESISTANCE TRAINING

Resistance training is any structure of exercise in which dynamic or static muscle contraction is resisted by an exterior force applied manually or mechanically. Resistance exercise, also known as *resistance or strength training*, is a crucial aspect of rehabilitation programs for people with impaired function and is an integral component of conditioning programs (Kisner, Colby 2007, 148).

The main aim of resistance training include improving muscle strength and endurance, while other health-related benefits resulting from resistance training include an increase in muscle, reduced blood pressure, and reduced body fat (Bird, Tarpenning, and Marino 2005, 842).

Resistance training involves the body or parts of the body moving against resistance. There are many benefits to resistance training, one being bones health. Physical activity, principally weight-bearing exercise, is considered to supply the mechanical stimuli or "loading" important for the upkeep and development of bone health, while physical inactivity have been implicated in loss of bone density and its related health costs (Layne, Nelson 1999, 25-30).

Resistance training has been linked to reduced adiposity and improved insulin sensitivity and is now a recommended mode of exercise for individuals with type 2 diabetes. Furthermore, resistance training promotes fast muscle fibres which are more responsive to resistance training paradigms (Albright et al., 2000 Schmitz et al., 2007). According to Tortora, Derrickson (2009, 325) fast muscle fibres are more responsive as they contain large amounts of glycogen and generate adenosine triphosphate (ATP) mainly by glycolysis. Fast twitch fibers contain the most myofibrils; hence they can generate the most powerful contractions. They are adapted for intense anaerobic movements of short duration but fatigue quickly, for example when doing strength training.

The most evident gains of resistance training are to the muscular system. Regular resistance training is connected with several positive Physiologic changes, below is a table explaining these (Hall & Brody 2005, 71). Refer to table 1.1

Table 1.1 Physiologic Adaptations to Resistance Training modified from Hall & Brody (2005, 71)

VARIABLE	RESULT AFTER RESISTANCE TRAINING
Performance	
Muscle strength	Increases
Muscle endurance	Increases higher power output
Aerobic capacity	No change or slight increase
Maximal rate of force Production	Increases
Muscle Fibers	
Fiber size	Increases
Mitochondrial density	Decreases
Capillary density	Decreases
Enzyme Activity	
Creatine phosphokinase	Increases
Metabolic Energy Store	
Stored ATP	Increases
Creatine phosphate	Increases
Stored glycogen	Increased
Stored triglycerides	Possible increase
Connective Tissue	
Ligament strength	Possible increase
Tendon strength	Possible increase
Collagen content	Possible increase
Bone density	Increase
Bone Composition	
Percentage of body fat	Decreases
Fat free mass	Increases

3 TYPES OF MUSCLE CONTRACTION

According to Chandler and Brown (2008, 49) the term muscle contraction implies muscle shortening. Muscles can create force while shortening, lengthening, or maintaining a given length. The smallest contractile unit in the muscle is called a sarcomere. A sarcomere is made from different proteins; the two significant proteins in a sacromere are actin and myosin, which create contractions of the muscle (Brown

2007:4). Muscles can do numerous kinds of actions, including concentric, eccentric, and isometric actions (Brown 2007:24).

3.1 Isometric contractions

Isometric (static) is a form of exercise in which tension increases in the muscle, but no mechanical work is executed. There is no noticeable joint movement, and generally the length of the muscle remains the same (Kisner, Colby 2007, 892).
Furthermore, Hall and Brody (2005, 87) mentions isometric exercises are generally used to enhance muscle performance. While no joint movement occurs, isometric exercises are considered functional because it provides a strength base for dynamic exercise because many postural muscles work primarily in an isometric fashion.

Isometric exercises are an important rehabilitation tool when joint motion is uncomfortable or limited during immobilization, or if a weakness exists at a particular point in the range of motion (ROM). Isometric exercises are used as a special technique in proprioceptive neuromuscular facilitation to enhance stability and strengthen muscles in a weak portion of the range. This resistive mode is easy to comprehend and perform correctly, requires no equipment, and can be done in nearly any setting (Hall and Brody 2005, 87).

3.2 Concentric and Eccentric Muscle Contractions

The term concentric describes a shortening muscle contraction, and the term eccentric describes a lengthening muscle contraction. Eccentric contractions vary from concentric and isometric contractions in several important ways. Per contractile unit, more tension can be generated eccentrically than concentrically at a lower metabolic cost (i.e. less use of ATP-derived energy). Eccentric contractions are a crucial factor of the functional movement pattern (e.g., required to slow limbs during movement), are the most energy-efficient, and can develop the most tension of the various types of muscle actions (Hall and Brody 2005, 59).

3.3 Concentric Muscle Contraction

As the speed of muscle shortening increases, the force a muscle can create is reduced. Torque also reduced as the muscle shortens at faster contractile velocity, perhaps because the muscle may not have sufficient time to develop peak tension (Kisner, Colby 2007, 165). Thibaudeau (2006,16) states the key to remember is that no matter what load is used, you should try to lift with as much speed as possible during the concentric portion of the exercise.

3.3.1 Eccentric Muscle Contraction

Results are not as consistent for eccentric than concentric muscle actions. Throughout an eccentric contraction, the speed of active muscle lengthening increases, force production in the muscle at first also increases however quickly levels off (Kisner, Colby 2007, 165).

Studies have been carried out to establish if one type of muscle action is mainly important for enhancing muscle strength and mass. It is possible to produce more force during eccentric and isometric muscle actions; it's said that these muscle actions may be more significant than concentric muscle actions for inducing changes in muscle strength and size (Stoppani 2006, 05). Figure 1 below is different muscle contractions and depending on the contraction being performed, will dictate the performance from the muscle being utilised during your workout.

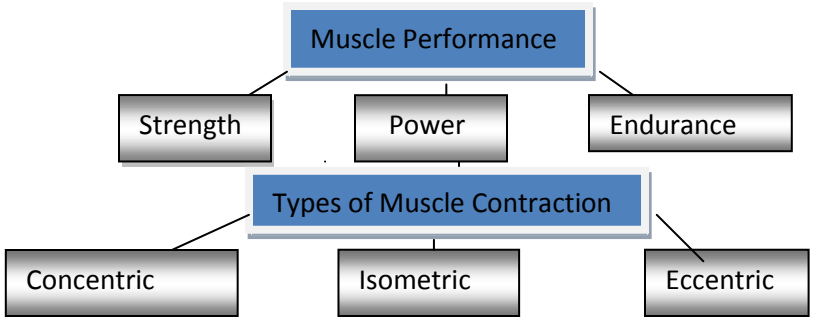
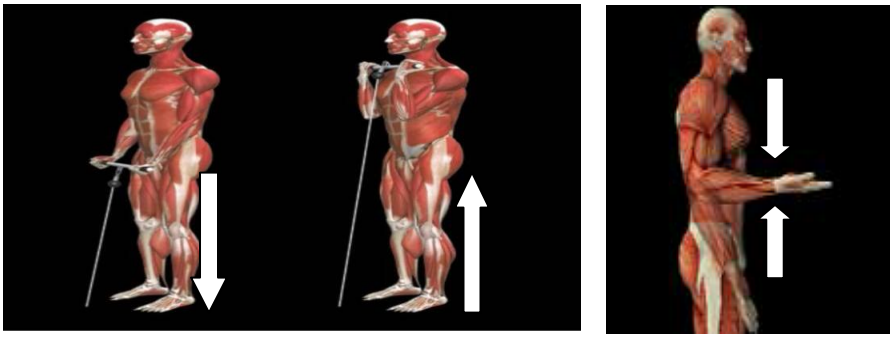


Figure 1 depicts the types of muscle contraction that may be performed in a resistance exercises and their relationships to each other and to muscle performance modified from Kisner, Colby (2007:164).



eccentric **concentric** **isometric**

Picture 1 Difference in muscle contractions adapted from (Thibaudeau 2006, 15, 16)

4. BIOMECHANICS

Biomechanics can be characterize as the study of the structure and function of the biological systems, the human musculoskeletal system, by way of (Newtonian) mechanics (Trew, Everett 2005, 42)

4.1 Classification of levers

In biomechanics levers are frequently classified in terms of the relative positions of a load, effort, and fulcrum. There are three basic classification for levers, first, second and third order. For the purpose of this thesis, we will only need to talk about second and third order levers (Trew & Everett 1997, 21).

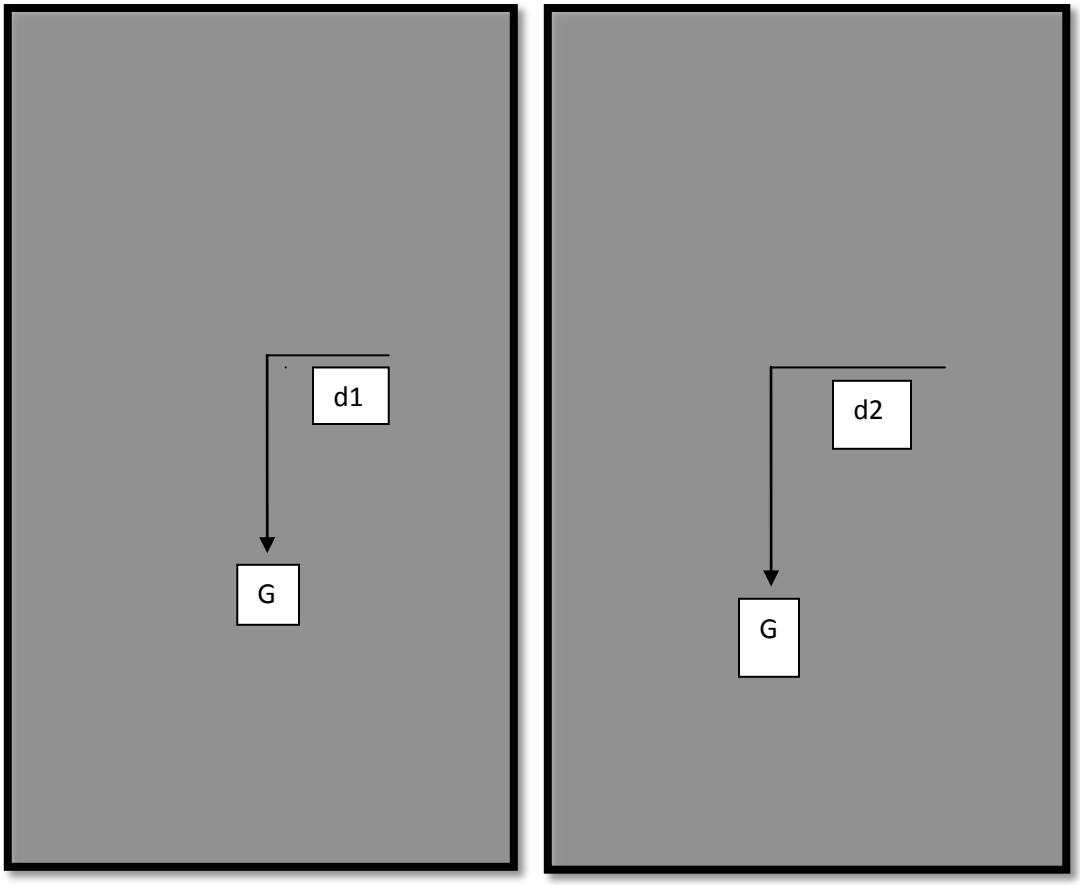
Trew & Everet (1997, 22) defines second order levers as levers where the resistance lies between the fulcrum and the force. The mechanical benefit of these levers is always greater than one, these are force levers. The effort applied will always be less than the resistance to be overcome. Muscles work as third class levers Trew & Everet (1997, 22) explains third order levers are always positioned between the resistance and the fulcrum. The action of the bicep muscle in flexing the elbow is an example of a third order lever

4.2 Sources of Resistance to Muscle Contraction

Zatsiorsky (2000, 118) mentions it is necessary to differentiate clearly between force and torque, since a muscle could produce constant torque around a joint over a certain range; however the muscle tension causing the action can differ significantly. Conversely, fairly constant muscle force or tension may produce considerably changing torque.

According to Timo Heinonen (personal communication on 24.02.14) if either the force or the length of the lever changes, there will be a change of torque. In picture 1, the shorter the grip, the less force comes from the arm. Picture 2 the wider the grip, the more force comes from the arm. In both diagrams, the direction of force changes because of the axis. The vertical component becomes smaller when the distance increases from the shoulder line.

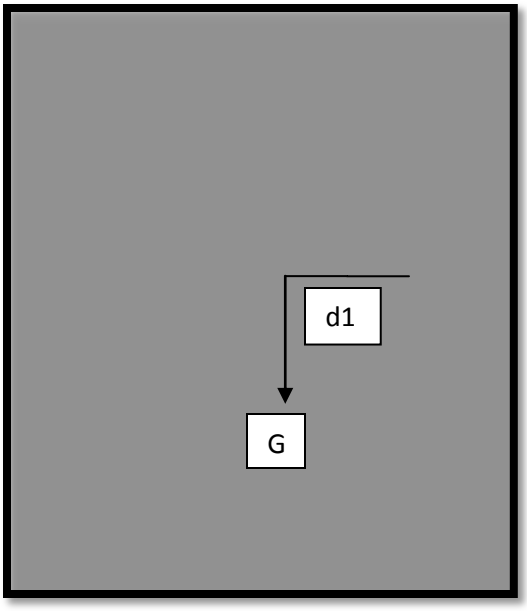
McGinnis (2013, 22) mentions external forces are those that act on an object because of its interaction with the environment surrounding it. Within sports and exercise, the only noncontact force we will involve ourselves with is gravity. The force of gravity acting on an object is defined as the weight of the object. Another example of gravity and its application to resistance training can be seen in the pictures below.

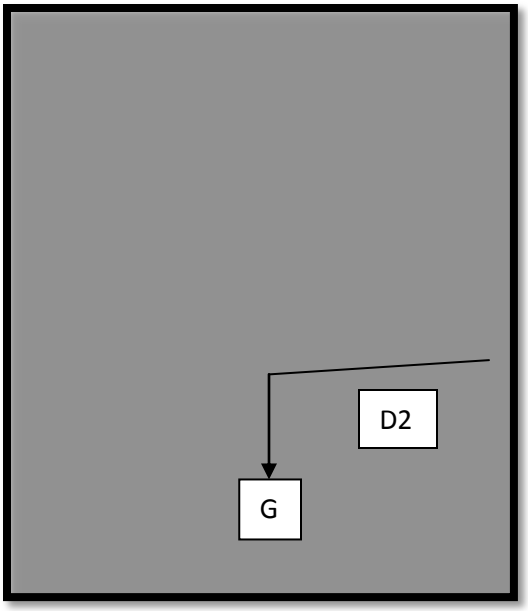


Picture 2 Dip with less resistance Picture 3 Dip with more resistance

(G = gravity, d1 & d2 = distance)

Picture 1 and picture 2 show the arrows pointing down are external weight (gravity) that stays the same. The line going across shows how the distance changes the grip (Timo Heinonen personal communication on 28.04.14)





Picture 4 Inverted row one fulcrum point

Picture 5 Inverted row three fulcrum points

Picture 4 shows when the weight is horizontally closer to the joint; it exerts less resistive torque. The elbow is the fulcrum that is in line with the wrist; there is no torque as they are in the same line (Timo Heinonen personal communication on 28.04.14). Picture 5 shows when the weight is horizontally further from a joint, it exerts more resistive torque. There are three fulcrum points at the shoulder, elbow, and wrist, it's more complex as they are not in line, and so more force is needed and more muscles are involved (Timo Heinonen personal communication on 28.04.14)

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5 EXERCISE TECHNIQUE MANUAL

The exercise manual utilizes your own body weight, with the option of resistance bands so there's no extra stress on your body. The reasons for choosing these exercises are they cover the majority of the major muscle groups. From a physiotherapy point of view this manual describes in detail the benefits this can have for example on balance, strength and the core muscles. It also educates the client in part about the physiology of the muscle(s) being exercised. Kisner, Colby (2007, 1) mention physiotherapist may be required by individuals who have no impairment(s), however want to improve their overall fitness or reduce risks of injury or disease. A therapist must also incorporate applied knowledge of anatomy, physiology, kinesiology, when developing exercise programs.

The exercises for the upper body include dips, inverted row, shoulder press, push ups, bicep and triceps curl. For the lower body exercises include, lunges, hurdling (jumping), and squat shoulder press. The reasons for including these exercises were the benefits, which include for instance, when performing the shoulder press. The shoulders are the most movable joint; they are very unstable since they rely on the surrounding muscles, tendons & ligaments for support, mobility & strength. For the lower body lunges improve your balance because the lunges put you in an unstable position. They Improve your lower body strength because the split stance works the legs independently, shifting the load on your body (Wellness Centre 2013).

The majority of these exercises can incorporate the core muscles physiotherapist know the importance the core plays in maintaining good posture and prevention of injuries. The core muscles are those which attach to the spine or pelvis. They are the foundation of stability and from where movement originates. A solid foundation of core muscles improves posture and creates capable movement for all activities (Wellness Centre 2013). Kisner, Colby (2007, 418) acknowledged studies that show exercising the core muscles for postural control and stability enhances the long-term outcome in client populations with acute and chronic lower back pain as well as pelvic girdle pain

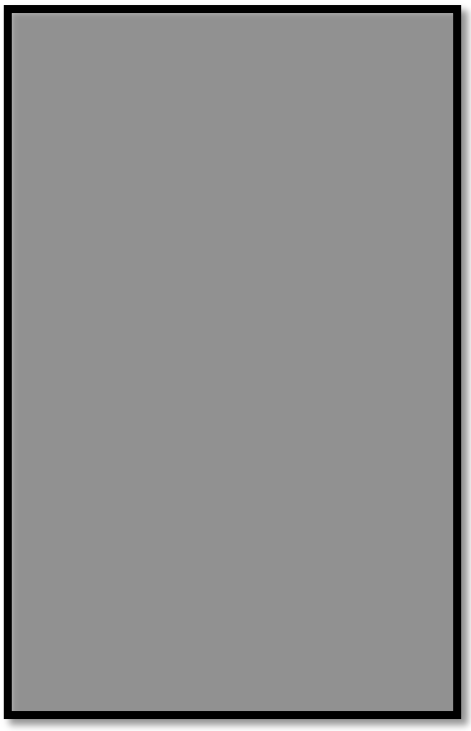
5.1 Description of the device and its intended use

Picture 6

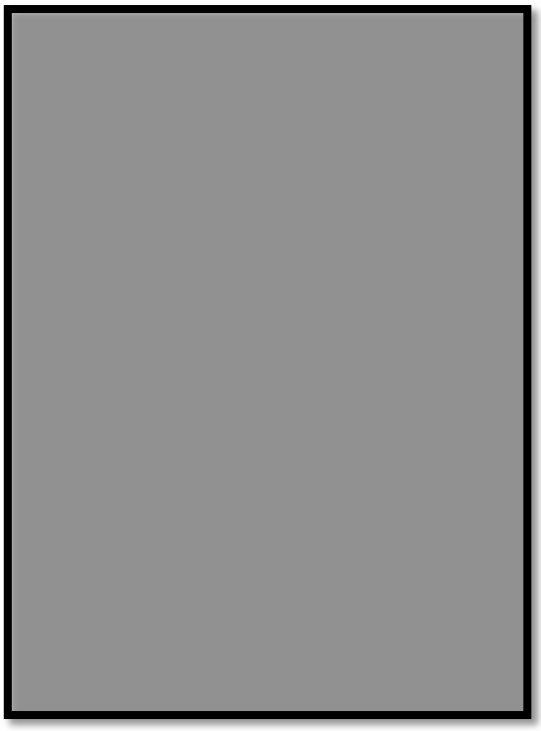
In picture six starting from the bottom section channel, the bottom part is meant to slide inside it from both ends. Then on top of the bottom section the screw clamp is to be inserted and then the middle section with another screw clamp upside down. The top section is inserted then on top of the middle section. Same procedure is to be carried out for setting up the assembly on the other side. The height and distance are adjusted as required.

Still looking at picture six the top supporting plate are placed on the very top section and is NOT clamped permanently, but just fixed by way of flexible clamps and can be

taken off when needed. The top supporting plate is for supporting the body weight while performing various exercises, such as back strengthening. The middle section has height adjustments so it varies the exercises that are done. The C section adjusts in and out length ways so you can use a close grip or wide grip stance utilizing different muscles. Maximum body weight is 105 kg According to Hardik Patel, mechanical engineer (personal communication on 07.09.2009)

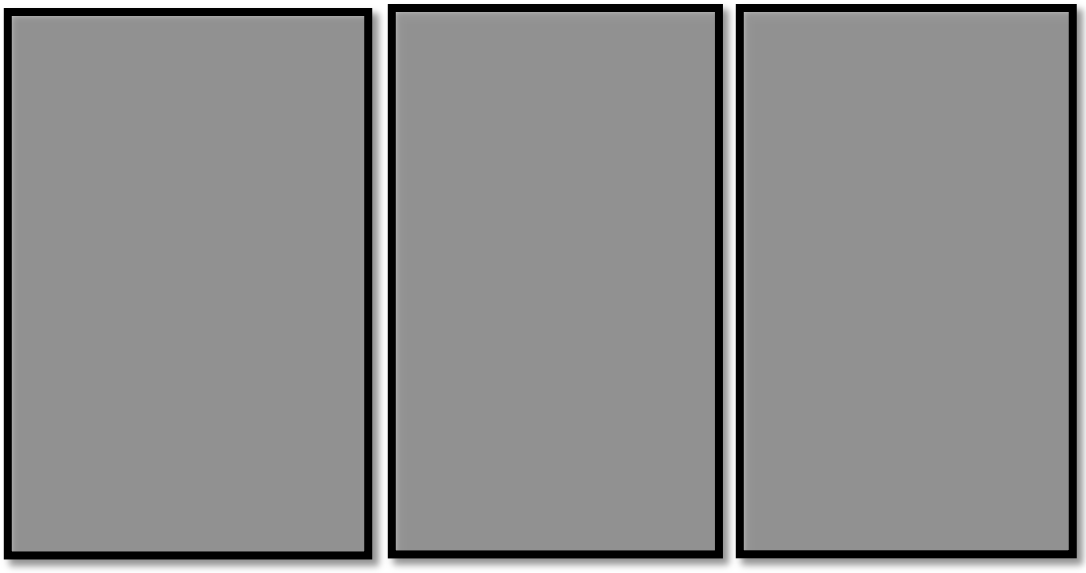


Picture 7



Picture 8

The pictures seven and eight above and pictures 9, 10 and 11 below show how the machine looks internally, how it adjust plus how the clamp and screw are there to prevent any wobbling when doing certain exercises such as dips.



Picture 9 Picture 10 Picture 11

5.2 The intended demographic to use this equipment

This piece of equipment is for people who don't have enough time to go to the gym, or people who would like to gain strength by lifting their own bodyweight. Also for people who may have suffered some form of injury and can no longer attend a gym. This can be used by a personal trainer or a group of people who may take this to the park and train under the supervision of a personal trainer incorporating other cardio exercises.

5.3 Advantages for using this equipment

Covering over twenty exercises it can be used at home or taken on holidays it's also easily dismantled to put away**.** Most gyms like to lock you into a gym membership starting at one month up to twenty four months which can make you feel obliged to go. According to Halme (2013, 21) one of the biggest problems for fitness centers is to keep their customers. That is why the competition between Fitness centers is so strong, and the most frequent way to obtaining customers is to make long-term contracts and memberships with them. These long-term contracts can be even up to 24 months.

Many simple bodyweight movements can be accomplished on this equipment and according to Peurala et al (2005) this can be an effective option for rehabilitation, even for those with significant impairments. Bodyweight exercises are safe for any person regardless of experience, age, or fitness level.

This equipment is ideal for people who want a more toned body shape rather than a muscular shape. This device can easily be modified to challenge any fitness level. By sliding the bars in or out gives the person more options for resistance. Shiraev and Barclay (2012, 960-2) mention by adding extra repetitions, performing the exercises faster or slow, and right form are a few ways to make even the simplest exercise more challenging.

6 THE PURPOSE OF THE THESIS

The purpose of this thesis was to create an exercise technique manual from a product I designed in the field of health promotion. The manual was designed for people who are interested in purchasing the product. The material in the manual is aimed to assist people in gaining maximum results from the exercise being performed. It also focuses on the practical use of the product which can be seen through photos of the exercises being performed.

7 DISCUSSION

I found having numerous commitments didn't leave enough time for the gym plus leaving equipment such as dumbbells around the house was becoming a hazard. My daughter was becoming inquisitive and was trying to lift them, so I found it was becoming too dangerous to have weights at home.

Since I have been physically active all my life, I found I couldn't go long without doing some form of resistance training, and I found just doing the generic forms of resistance training (lifting weights) becoming repetitive. I got to thinking how could I combine all or some of the cardio and resistance exercises I used to do whilst playing rugby league.

In 2008, the idea dawned on me, in 2009 I hired a mechanical engineer to put my thoughts onto paper, and then March of 2011 a prototype was made. There are still some design issues to deal with, but on the whole the design meets my requirements.

Some of the obstacles I faced when I thought of this concept were initially how do I get this designed. My friend an architect made the initial design in April 2009; then I had a foundation to work from. I needed a mechanical engineer to help with certain specifications, for example what weight could this design hold safely without breaking. I met numerous mechanical engineers to no avail as my project was too small or I just couldn't afford the price they were asking.

I decided to place an advertisement at Queensland University of Technology (QUT) I received an email from a final year mechanical engineer student. When we met, I discussed what my thoughts were in regards to specifications of the design. He decided he would be interested in helping with the design, from there it took roughly seven months to come up with a design that may work.

Some other obstacles faced were when the design reached its maximum height how was it possible to stop it from swaying when, for example, doing dips. The next obstacle was getting it made; no one seemed interested in making a one off protocol. I managed to find one company willing to do it at a set price; however, when the Fitter and Turner viewed the design he noticed some segments that would need modifying.

I met with the mechanical engineer, and the modifications took a further two months. Finally done I went back to the Fitter and Turner, who had just received a large contract and would be unable to make my design. March 2011 finally someone was willing to make my protocol, the mechanical engineer and I tested the design; it did the exercises needed, however, it still needs a little modification.

7.1 Thesis Process

When I started at the Satakunta University of Applied Sciences (SAMK) knowing I had to do a thesis I instantly thought I could use my design as a thesis project. After

our first thesis meeting, I spoke to a teacher about the potential of using this design. We spoke about the direction the thesis should go in.

Since the prototype was in Australia, I had to wait till June 2013 to take photos for the exercise manual. I arranged for photos to be taken in July 2013. Writing for the thesis started in October 2013 which included editing photos for the exercise manual. December 2013 and January 2014 where dedicated to study. From February, more writing took place, and since I didn't have the prototype in Finland it was decided I use video footage for the presentation. The last two weeks of February were dedicated to making a video of the design including photos and text. March, April, and May were dedicated to finishing off the exercise manual and thesis.

Further research can be done by another student who may be interested in comparing this design with conventional weight lifting. Factors to explore can be comparing body mass index (BMI), improvements in balance, general fitness and the gains in strength before and after a twelve week period.

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