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A THESIS

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Study on the Exercise Physiology of Jeju Crossbred Horses and the Effect of Riding for the Disabled

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Study on the Exercise Physiology of Jeju Crossbred Horses and the Effect of Riding for the Disabled

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ABSTRACT

This study is conducted in order to analyze the effects and exercise physiology of riding horses for the disabled and to provide fundamental data for riding for the disabled and welfare of horses through the utilization of Jeju Island crossbred horses that have appropriate body types for horse riding and riding for the disabled. For exercise physiology, we confirmed physiological changes of a horse based on the recovery duration after intensive exercise (experiment 1) and effects on health via swimming trainings on horses by analyzing physiological changes based on the swimming training duration (experiment 2). Furthermore, for riding for the disabled, we analyzed the effects on children with cerebral palsy based on the duration of horse riding (experiment 3) and changes in balance, agility, coordination, and flexibility of children with intellectual disabilities (experiment 4). The results of this study are shown below.

In experiment 1, to identify physiological changes in horses after intensive exercise based on recovery duration, we measured the heart rates (HR) of participants and took blood samples after 3,000 m of horse riding (gallop, 10.0m/sec) by using 2 males and 23 females.

Blood glucose levels and blood lactate concentration were measured on the spot. In order to check dehydration and anemia of horses, packed cell volume (PCV), blood glucose levels, blood lactate concentration, total protein (TP), and hemoglobin (Hb) were analyzed at the veterinary clinic laboratory (Chapter 3).

The horses were divided into five groups as follows: passive rest (standing tied rest) immediately after exercise (PR), rest after 15 minutes walk (WR 15), rest after 30 minutes walk (WR 30), rest after 15 minutes trot (TR 15), and rest after 30 minutes trot (TR 30).

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According to the study results, all groups showed sharp decreases of heart rates after 15 and 30 minute rests. The recovery rate of heart rates based on the resting duration from the peak level was higher in active cooldown groups than in passive groups. In the case of glucose, the recovery rate was higher in WR 15 group after 15 minutes of rests and in WR 30 group after 30 minute rests from the peak. Therefore, light exercise was the most effective among all elements studied. TR group showed 75% decrease of lactate after 15 minute rests from the peak and PCV was not significantly different between the groups.

It is considered that a horse stores up to 1/3 of red corpuscles in a spleen and the red corpuscles quickly outpour into blood to carry more oxygen and rapidly return back when the exercise finishes. In this study, physiological changes after intensive exercises were clearly varied based on the cooldown methods. Thus, it is considered that the active cooldown is essential for quick recovery of fatigued horses, and for short term recovery, trot or free walk is to be the best cooldown method.

In experiment 2, five mare riding horses with minimum 3 year experiences were used to identify physiological changes of Jeju crossbred horses based on the swimming training duration. The swimming training was conducted 10 minutes a day (60.0 m/min) For 14 days (Chapter 4). Physiological characteristics and blood variables were measured before, at, immediately after swimming and after 10 minute rest on the first, 7th, and 14th day of training.

Heart rates ($p < 0.05$), blood glucose level ($p < 0.05$), blood lactate concentration ($p < 0.001$), PVC ($p < 0.001$), and Hb ($p < 0.01$) were measured before swimming training (D_0) and after swimming training 14th day (D_{14}) and they were a lot lower than before swimming (D_0). Because the lactate creation rate right after swimming was noticeably lower at the 7th and the 14th day compared to the first day of training, the result demonstrated the training effects by the duration as well. Because PCV and Hb values were remained within the normal range from the 7th to all sessions, it confirmed no possibility of anemia or dehydration. TP was also remained within the normal range in all sessions. Therefore, it

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suggests the positive effects of the swimming training in spite of relatively short training period.

In the experiment 3, we conducted riding for the disabled twice a week (30min Per one session) for 8 weeks to children with spastic cerebral palsy in order to identify improvements based on exercise duration. Furthermore, we measured using the Denver Developmental Screening Test (DDST), Gross Motor Function Measure (GMFM), Range of Motion (ROM), and Spasticity Test (ST) before (TR0), after 4 weeks (TR1), and after 8 weeks (TR2) of riding for the disabled in order to measure its effects (Chapter5).

The result of DDST showed that the individual/society development of DDST was higher after 8 weeks of riding for the disabled than TR0. In the GMFM comparison, dimension C (crawling and kneeling), D (standing), and E (walking, running, and jumping) illustrated significant changes after riding for the disabled. ROM and ST, however, showed that 16 sessions of riding for the disabled were not enough to bring meaningful changes. In addition, gross motor function development was closely related to personal-social (PS), fine motor-adaptive (FMA), and linguistic ability.

In experiment 4, we conducted riding for the disabled with children with intellectual disabilities in order to analyze changes in balance, agility, coordination, and flexibility. Three male and three female students from specialized classes of primary school participated in the study (Chapter 6).

RD program sessions were provided twice a week, 30mins per session for 8 weeks and all sessions were conducted by PATH International-registered instructors. Balance, coordination, agility, and flexibility were evaluated before sessions (T0), after 8 sessions (T1), and after 16 sessions (T2) of RD.

According to the balance measurement results, participants maintained their balance longer after riding for the disabled than before the program. Comparisons of coordination or reflex measurements presented meaningful changes after riding for the disabled as well.

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Agility was improved after riding for the disabled but it was not significant. Also, agility was improved after riding for the disabled than before. According to these results, it is confirmed that riding for the disabled improves physical strength of children with intellectual disabilities.

In summary, the study results can provide application of appropriate rest method for fatigued Jeju crossbred horses and utilization of Jeju crossbred horses for rehabilitation therapy for children with cerebral palsy and intellectual disabilities in order to improve their motion function and motor physical fitness. Furthermore, this study can be useful basic data for locomotion capacity of a horse and riding for the disabled.

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LIST OF ABBREVIATIONS

AAA	Animal Assisted Activities
AAT	Animal Assisted Therapy
AAMD	American Associated on Mental Deficiency
AHA	American Hippotherapy Association
APA	American Psychiatric Association
BMI	Body Mass Index
bpm	beat per minute
CP	Cerebral Palsy
DDST	Denver Developmental Screening Test
Dimension A	Lying and Rolling
Dimension B	Sitting
Dimension C	Crawling and Kneeling
Dimension D	Standing
Dimension E	Walking, Running, and Jumping
EAA	Equine-Assisted Activities
EAL	Equine-Assisted Learning
EAP	Equine-Assisted Psychotherapy
EAT	Equine-Assisted Therapy
EFL	Equine-Facilitated Learning
EFP	Equine-Facilitated Psychotherapy
HAB	Human-Animal Bond

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Hb	Hemoglobin
HR	Heart Rate
ID	Intellectual Disability
FMA	Fine Motor-Adaptive
FRDI	Federation riding for the disabled International
GM	Gross Motor
GMFM	Gross Motor Function Measures
Lang.	Language
NARHA	North American riding for the Handicapped Association
PATH *Intl.*	Professional Association of Therapeutic Horsemanship International
PCV	Packed Cell Volume
PS	Personal-Social
RDA	riding for the disabled Association
ROM	Range of Motion
ST	Spasticity test
TP	Total Protein
TR	Therapeutic Riding
VO2	Volume of Oxygen Utilization

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INTRODUCTION

The home of the horse, Jeju Island, has been blessed by heaven with a magnificent natural environment to breed livestock because of its wide spread pastures and sufficient precipitation.

Jeju crossbred horses have small heights with strong body. Furthermore, they are generally known for their great adaptability into rough breeding conditions such as yearlong grazing. Their hooves, especially, are very solid so, they are able to adapt into the typical rocky Jeju environment. Also, the small height of Jeju crossbred horses allows even beginners to ride them without any difficulties and they are preferred by horse riding lovers because they have been demonstrated strong endurance through solid hooves. Jeju crossbred horse is a breed cross which is produced by hybridization of Jeju horse and Thoroughbred. They are highly acclaimed for their qualifications for the riding horse and they are appropriate for endurance riding as well.

Because gaits of the horse in the horse riding are three dimensional movements which are similar to human movements, a rider can expect analogous exercise efficacy with walking exercise (Riede, 1988; Engel, 1997). The overall effect of exercise related to riding provides physical, mental, and psychological stability and benefits to able bodied people as well as to the disabled. Because the number of disabled is continuously increasing, the Ministry of Health and Welfare is making efforts to promote the welfare of disabled people through sports and others in order to protect the rights of the disabled and to set up a favorable environment that encourage their involvement in society (Ministry of Health and Welfare, 2003). Although various therapies, facilities, and legal functions have been developed for treatments for disabled people, there are many environmental limitations

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associated with sports activities of disabled in reality (Lim and Han, 2004). In particular, the number of cerebral palsy has increased over the last two decades, according to recent studies.

Cerebral palsy (CP) causes posture and motor disturbances as well as multiple disabilities (Hernandez-Rief *et al.*, 2005; Poulos *et al.*, 2006) and it is the most common disorder affecting children (Wood, 2006). Moreover, children with intellectual disabilities tend to have high obesity rates because of their motor development retardation. For this reason, various remedial exercise programs are being offered and a program that encourages riding for the disabled (RD) that uses the movements of the horse is being recognized as a new alternative therapy (Han *et al.*, 2004).

RD, uses the horse as an instrument of the therapy. CP and intellectual disorders have common characteristics; they are not temporary symptoms and their conditions can be improved through education or therapies but they are inextirpable diseases. However, range of joint motion, motor skills (Hernandez-Rief *et al.*, 2005). Social interaction, fundamental motor capacity, and self-contentment are meliorated through physical activities of a child. Therefore, physical barriers derived from disorders can be minimized through systematic and continuous exercise programs.

Most of precedent studies on the Jeju crossbred horse, however, are limited to genetic study (Cho, 2003; Yang and Kim, 2004), biostatics of Jeju horse figure (Lee, 1967), and horse riding study (Oh *et al.*, 2009; Kang *et al.*, 2010). Also, a quick recovery to the pre-exercise state is essential to an exhausted horse after diverse exercises (outdoor riding, endurance riding, etc.).

Unfortunately, studies on the treatment of the fatigued horse and RD are on the side of nonexistence. Thus, this study uses Jeju crossbred horses which have appropriate body type for the horse riding and riding for the disabled in order to

1) confirm physiological variations by recovery periods after intensive exercises (Chapter 3),

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2) confirm physiological variations by swimming training period (Chapter 4),

3) confirm development progress of children with CP through RD (Chapter 5), and

4) analyze balance, agility, coordination, and flexibility variations of children with intellectual disorders through riding for the disabled (Chapter 6).

This study verifies welfare and training methods for fatigued horses by synthesizing the results and provides the fundamental data for RD.

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CHAPTER 2

LITERATURE REVIEW

1. EXERCISE PHYSIOLOGY OF HORSES

1.1 Exercise Capacity of Horses

Performance of a horse depends on various factors including health, nutrition, and environment. Energy means a capacity to do tasks. The amount of energy for muscular motion is the most important factor for the performance of a horse (Jose-Cunilleras and Hinchcliff, 2004).

Human beings and horses use carbohydrates as an energy source for anaerobic glycolysis in the form of muscle glycogen during strenuous exercises. On the other hand, horses can experience decreases of muscle glycogen concentration up to 50% by repetitive maximal intensive exercise or cyclic sprints along with long-distance running (Snow and Harris, 1981; Davie *et al.*; 1995; Lacombe *et al.*; 1999). Furthermore, many horses perform quite a few tasks a day and an insufficient intermission between each exercise can cause incomplete recovery of the muscle glycogen pool (Snow and Harris, 1981).

The loss of muscle glycogen can result in low-quality performance following high intensive exercise regimes. However, the matter has yet to draw significant attention. In fact, the loss of muscle glycogen concentration by 22% did not have significant effect on high-intensity exercise duration (Davie *et al.*, 1995).

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Conversely, the loss of muscle glycogen by 55% from its initial value can cause diminution of anaerobic power generation during consequent high-speed exercise (Lacombe *et al.* 1999). For muscle contraction, mass energy is transformed from chemicals to kinetic energy through metabolic pathways. Hence, exercise needs an effective use of energy. Muscles can only store partial adenosine triphosphate (ATP) but all motions need a stable flow of energy sources.

Energy is categorized to aerobic and anaerobic based on oxygen utilization. Anaerobic process synthesizes energy within cytoplasm without oxygen whereas aerobic process synthesizes energy within mitochondria with oxygen (Jeong and Yoon, 2006).

According to Jose-Cunilleras and Hinchcliff (2004), the duration of mid-intensive exercise can be increased by supplementation of glucose through intravenous administration during the exercise. On the other hand, glucose replenishment through pre-exercise soluble carbohydrate-rich meal is not verified its effect yet. At mid- and high-intensive exercises, pre-exercise low muscle glycogen concentration in a horse is related to diminution of time to exhaustion. Furthermore, nutritional interventions for muscle glycogen synthesis was unsuccessful in horses compare to other species.

Muscle glycogen replenishment to horses after hard exercise was incomplete until 48~72 hours while human and laboratory animals completed within 24 hours. Thus, the low muscle glycogen replenishment rate of horses are related to low absorbing capacity of starch and other glucose-related nutrition, low muscle glycogen synthesize ability, or a combination of both.

During the aerobic exercise, glucose is decomposed by the glycolysis process for producing energy. However, lack of oxygen during anaerobic glycolysis can turn glucose into pyruvic acid (Guyton, 1981). This pyruvic acid, in turn, produces lactic acid under the condition of insufficient oxygen, or is decomposed through the aerobic process when provided with sufficient oxygen.

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Accumulated lactic acid acidifies body tissues and blood causing physical fatigue and deterioration of exercise performance. Medium level exercise in terms of type and intensity does not cause a problem. However, during high intense exercises the quantity of lactic acid increases sharply (Karlsson *et al.*, 1972).

1.2 Exercise Physiology of Horses according to Cooldown Regiment

Compared to human sports medicine, the exercise capacity evaluation for physiological responses of a horse was adopted very recently. The exercise capacity evaluation of human measures exercise physiological data including oxygen consumption, heart rates, and blood lactate concentration in order to evaluate suitability and latent exercise capacity (Wasserman *et al.*, 1994).

The exercise capacity evaluation for horses measures latent exercise capacity related metabolism indicators and examines responses to a training (assistant) program. The processes and methods for the evaluation must be able to apply to horses with low exercise capacity and to attain results in a relatively short period of time. Moreover, it has to measure metabolism indicators that represent exercise capacity (Seeherman *et al.*, 1990). Therefore, heart rates, blood lactate concentration, and respiratory index systems have been used for during the exercise capacity evaluation for horses.

Persson (1967) initially used a treadmill for the exercise capacity evaluation of horses and standardized the examination environment. He measured heart rates, blood lactate concentration, and PCV of Standard bred horses under sub-maximal exercise conditions. Evans and Rose (1988a; 1988b) examined the respiratory system of Thoroughbred horses at maximal intensity based on exercise and training through the use of high speed treadmills.

Generally, the heart rate determines metabolism and athletic ability of an athlete and it is considered an important indicator related to exercise prescription (Fox and Mathews, 1981).

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Exercise is closely related to energy and aerobic and anaerobic metabolism (Hinchcliff *et al.*, 2002). At this point, a horse's heart rate is practically the best means of evaluating the horse's physical condition, understanding of the horse's heart beat during training and recovery stage is useful in evaluating the enhancement of fitness of a horse resulted by training and its training condition.

According to Kim *et al.* (2004), the 5 min cooldown group showed meaningful variations compare to a group without the cooldown method. Stimulation information from muscle and joint-receptors are conveyed to brain and then cardiomotility nucleus suppresses parasympathetic nerve. As a result, the process increases the heart rates. Therefore, the heart rate increases in proportion to the exercise intensity (Wilmore and Costill, 1999). However, the heart rate to the exercise intensity decreases as the one adjusts to the exercise and the recovery becomes faster after exercise.

Blood lactate accumulation related several variables are used for indicators of exercise capacity in sports medicine (Yoshida, 1984). The variables are also used to compare changes in exercise capacity of horses (Person, 1983; Hodgson and Rose, 1994). The heart rate above 75~80% is Lactate Threshold (lactate concentration, 4mmol/L) and it implies that anaerobic metabolism had occurred (Gondim *et al.*, 2007; Ferraz *et al.*, 2008).

One way of eliminating the accumulated lactic acid is to recycle it as an energy source by inhaling sufficient oxygen through aerobic system (Hogdson and Rose, 1994). Fox and Mathews (1981) stated that the rapid lactate removal occurs during the rest period because lactate is used as a fuel for aerobic metabolism. Cooldown method after a strenuous sport gradually decreases loads on physical organs and consequently leads to a steady state (Karpovich and Hale, 1959). It is reported that cooldown exercise has a significant effect on eliminating lactic acid produced after exercise (Glsolfi *et al.*, 1966). Kim *et al.* (2004) reported that cooldown method group showed 29% decreasing rate compare to a group without the cooldown method after 20 min exercise.

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Lactate removal after exercise is very important because it restrains glycolysis and facilitates oxidation pathway. In sports medicine, William et al (1989) confirmed rapid removal of blood lactate concentration in volume of oxygen uilization (VO2) max 30~40% programs and demonstrated that active rest is more effective for lactate removal than passive rest. Denovan and Brooks (1983) argued that amounts of produced lactate during Standardized Exercise Test (SET) are identical but blood lactate concentration decreases because the lactate removal efficiency increases by training. Moon *et al.* (1999) stated that the average speed variations during blood lactate concentration increases up to 4 ~ 12mmol/L were higher in the training group by 47.7% in SET stating anaerobic metabolism efficiency was higher as well.

1.3 Physiological Parameters of Horse according to Training

The evaluation of the horse's physical training condition can be done by frequently measuring the concentration rate of PCV, TP, Hb, which indicates the horse's oxygen-carrying capacity and its level of dehydration and anemia.

Blood is divided into plasma, while blood cells, platelets, and red blood cells by centrifugal filtration. The proportion of red blood cells in 100ml blood is called PCV. Hence, PCV can be decreased by disease symptoms such as anemia or it can be increased by dehydration. In the case of horses, PCV and hemoglobin are measured to evaluate oxygen transport ability. Increases of PCV commonly means loss of body fluid by dehydration. The loss of body fluid increases blood concentration and viscosity and then cardiac output and tissue perfusion are decreased. PCV of horses are normally ranged within 32 ~ 48%.

Evans *et al.* (1993) measured PCV and Hb of 26 Thoroughbred racehorses at 2 min and 5 min after 800m gallops. The result showed that it had the highest correlations with blood lactate concentrations at 2 min and 5 min However, according to Nostell *et al.* (2006), to compare the physiological responses of a standardized treadmill exercise test used to

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simulate racing conditions and a simulated race performed on a track on the same Standardbred trotting horses, all in racing condition. No differences were observed in HR, Hb, PCV, TP, glucose concentrations after exercise and during recovery between the tests.

Training makes to adjust through stimulations. The stimulations need specific time and appropriate intensity in order to overload to response system. Metabolic efficiency improves through training because regulatory enzyme increases in other metabolic passages. Response and adjustment of regulatory enzyme to training is very indisputable to endurance that stimulates changes of intensive exercise and aerobic pathway.

Evans *et al.* (1993) compared training results of 9 weeks high- and low intensity treadmill exercise. Evans confirmed that the intensity was not mattered at the beginning stage of training because both groups increased VO2 by 20%. Geor *et al.* (1999) reported that VO2max increased by 8.9% by training a horse for 10 days (1hr/day) consecutively at 55% of mid-intensity VO2max. The result implies that mid-intensity based endurance can be more important to induce VO2max adjustment than high-intensity training. Various trainings are being conducted to improve exercise capacity of race horses.

Asheim *et al.* (1970) examined swimming for three periods of four minutes with three minutes rest between swims and reported lactate ranges from 3.0 to 9.3 mmol/L after the third swim with heart rates ranging from 158-210 b.p.m. Thomas *et al.* (1980) demonstrated that stroke volume decreased at low intensive tethered swimming. He also found that the volume was recovered to pre-exercise value when intensity was increased to high levels.

Studies on human biology illustrated that the highest medium VO2 during swimming was about 90% of the highest medium VO2 during cycling. Maximum swimming and maximum cycling had the same order of blood lactates (10mmol/L). Davie *et al.* (2008) and likewise mentioned that sympathetic and parasympathetic nervous systems control the heart rate in relation to circulating catecholamine.

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Swimming is the most popular cross training method that has been employed by many trainers. Swimming is considered the most appropriate training method for the cardio-vascular (heart-lung) fitness improvement of horses. Moreover, it minimizes the daily stress on horse legs from regular track training. For instance, 10 minutes of swimming has the equivalent effect of hours of trot or canter on the track, with much less physical impact.

2. ANIMAL ASSISTED THERAPY AND EQUINE ASSISTED THERAPY

2.1 Human-Animal Interaction (HAI)

Human beings have formed intimate relationships with animals for thousands of years. Research on human-animal interaction is defined as a study of animal utilization for physical and mental health as well as for physical and psychological therapies. Many researchers have found positive effects on animals (Cooley, 1993; All *et al.*, 1999; Bierer, 2000) and the animal therapies showed high success rates while other therapy methods failed in the treatment of children.

Historically, animals have played important roles in our lives. Mayer and Salovry (1997) stated that an emotional education for children is desirable through experiences in the nature and Cho (2004) reported that contact with animals develops a child-animal relationship, animal cherisher mentality, and extensive human relations. Loyer-Carson (1992) demonstrated that there is a distinct relationship between mental states of loving companion animals and affirmative cognizance of family. Moreover, Cooley (1993) reported that a family that more frequently interacts with companion animals maintains better relationships each other.

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Meanwhile, Robin and Bensel (1985), Poresky and Hendrix (1990) emphasized that raising companion animals and interactions through attachments should be separated. The study of Albert and Bulcroft (1988) which pointed out a function and a role of the companion animal as a family member and the study of Bierer (2000) which reported the higher score of dignity of a child who had a good bond with a companion animal demonstrated that the HAI develops a healthy and happy family system by giving positive effects to a child as well as other family members (Ryder, 1985). As the studies on human and animal health continue, an international scholastic society, Delta Society, has established. Delta Society is a large-scale international organization which is also the largest nonprofit organization for HAI in United States.

In 1977, Delta Society of United States was founded in Portland, Oregon under the name of Delta Foundation. The 'Delta' was originated from the primary purpose of Delta Foundation which means the triangular interrelations between pet owners, pets, and interest groups. Since then, studies on various fields (veterinary science, psychiatry, clinical psychology, etc) were initiated to explain the HAI and as a result, a new discipline called Human-Animal Bond (HAB) was established. The HAB was significant to a survival of human in the past but it is still important today as well.

2.1.1 Human-Animal Bond (HAB)

HAB goes beyond a simple comradeship and it enhances a quality of life through positive interactions between a human and an animal. In other words, promoting the human-animal bonds creates positive effects to all members of the community (Delta Society, 2000).

The bond between a human and an animal is an imperative influential factor for the ego development and it is a constructive nonverbal interaction (Monte, 1980). In particular, the bond with a companion animal can be influenced by parents. In other words, parents who are positive to companion animals let their children raise companion animals and they also

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deliver affirmative HAB as well, whereas negative parents gives pessimistic human-animal bonds to their children (Kidd and Kidd, 1990). From this Poresky and Hendrix (1990) argued that the child-companion animal bond is an influential factor relating to child development. HAB means an enhancement of human health through animal services and therapies (Delta Society, 2000).

The Delta Society introduced these research achievements into the medical and welfare fields according to the product of research that human and animal contacts provides mentally and physically positive effects to both a human and an animal. In 1987, the Delta Society initially supported the development of the horse assisted therapy curriculum (Delta Society, 2000), and supported two fields of HAB study: Animal assisted activities (AAA) and animal assisted therapy (AAT), according to the Society's national standards committee.

2.1.2 Animal Assisted Activities and Animal Assisted Therapy

AAA and AAT utilize animals as mediums of the therapy by an instructor who has completed the required courses of the Delta Society. AAA and AAT are similar but there are differences between them.

AAA enhances the quality of life by improving people's emotional stability and physical development through the HAI. Therefore, it is not a professional therapy but it provides enjoyable time with companion animals that places emphasis on entertainment, education, and prevention (An *et al.*, 2007). The activity is classified into passive assisted activity and interactive assisted activity. The passive assisted activity means an experience of emotional stability through enjoyments of the nature such as singing birds or swimming fish. The interactive assisted activity signifies a positive activity that motivates physical activities and develops skills through a direct relationship with an animal (An *et al.*, 2007).

AAT is a therapy and rehabilitation method which is widely used for physically disabled persons and even for mental patients such as dementia. Wide range of animals

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including horses, cats, dogs, birds, and fishes are used and the methods are varied as well. In AAT, the therapy can be classified into treatments for brain lesions, learning disabilities, emotional disturbances, autisms, developmental disorders, and intellectual disabilities and rehabilitations for surmounted of physical and mental disabilities in order to help them to lead a happy life (Kim *et al.*, 2010).

Hence, AAT is developed for physical, psychological, and cognitive function improvements through interactive activities between a patient (object), a therapist (assistant), and a companion animal (medium). Therefore, it is considered as a professional therapy in medical, welfare, and rehabilitation fields that utilizes the companion animal as the medium which holds specific qualifications and requirements (Cole and Gawlinski, 2000).

According to precedent studies, a child who raises a companion animal shows improvements in self-confidence and sociality (Madder *et al.*, 1989; Triebenbacher, 1998) and a patient with Alzheimer shows an enhancement in attentiveness (Kongable *et al.*, 1990; Batson *et al.*, 1995). As the efficacy of AAT proved, AAT is increasingly employed as an alternative rehabilitation method. Riddick (1985) reported that raising fish lowered the blood pressure of an elderly man. Furthermore, AAT augmented laughing and conversation skills according to Fila (1991) and it also increased the vitality of a patient with gait disturbances in accordance with the study of Raina *et al.* (1999). By putting the studies together, AAT says is possible to apply to various fields of human society and the various activities using animals are proliferated. In addition, it can be said that it emphasizes the necessity of AAT. Types of animals used for AAT is quite broad. AAT has been widely applied to enhance physical, psychological, cognitive functions as well as sociability of disabled people.

One aspect of AAT, hippotherapy was introduced by RD, therapeutic riding (TR), and horse therapy. However, the hippotherapy of RDA, the official name, focuses on the rehabilitation rather than the treatment. In hippotherapy, the horse is a therapist itself and plays an important role.

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AAT which is defined as a therapy using animals has attested eye-opening effects for cognition, psychology, and sociality (Fine, 2006) and TR which focuses on physical, psychological, and social development that forms a bond between a rider and a horse and arouses self-confidence and a sense of accomplishment within a rider (All *et al.*, 1999). In AAT, the use of horse is called RD.

2.2 Equine-Assisted Activities and Therapy (EAAT)

Equine assisted therapy (EAT) is a branch of AAT and it is considered as a successive attempt. Globally, many people have experienced the effects of EAAT. Particular physical, cognitive, or emotional problems cannot constraint a human to share communion with a horse and the communion goes a long way with a person.

Especially, the rhythmical and repetitive movements of the horse stimulate sensory nerves and it creates similar effects with human walking (Riede, 1988; Engel, 1997) and as a result, a rider with physical disability experiences enhancements in flexibility, balance, and muscular strength (Bertoti, 1988). North American riding for the Handicapped Association (NARHA) assorted the services into two areas: EAA and EAT.

2.2.1 Equine-Assisted Activities (EAA)

EAA is a recreation, leisure, sports and education services that are conducted by trained specialists. EAA is consisted of TR, carriage driving, vaulting, and equine facilitated learning and these activities are based on the educational model. The lessons are conducted by NARHA-licensed instructors. The professional training is purposed to develop riding skills and enhance the quality of life of disabled through specialized and adjusted teaching processes.

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EAA is a branch of AAA and it can be provided by a licensed instructor who completed special education. In addition, it is divided into EAT, equine-assisted psychotherapy (EAP), equine-assisted learning (EAL), equine-facilitated psychotherapy (EFP), and equine-facilitated learning (EFL).

2.2.2 Equine-Assisted Therapy (EAT)

EAT is a therapy that integrates horse-activities and horse-environments. It depends on the standard agreements of medical specialists in a relation to the purposes of objects. Lechner *et al.* (2003) stated that there is a difference between Therapeutic riding that teaches riding skills to disabled persons and EAT which is a psychotherapy using the movements of horse. EAT is a general term that includes Hippotherapy, Therapeutic riding, and other horse-related activities and it provides progressive unique riding experiences to people with physical or mental disabilities.

The primary purpose of EAT is to transcribe curative effects to an object by using a horse as a medium of the therapy and to provide mental, physical, and psychological effects to people with disabilities by utilizing natural behaviors of a horse that affects a rider as a treatment (Heine, 1997; Debuse *et al.*, 2005; Debuse, 2006).

Because the gait of a horse is similar to that of human, riding exercise helps and improves natural movements of spine and pelvis of therapy objects (Freeman, 1984; Kang, 2000). Besides, the integrated team composed of a rider, a horse, an instructor, and volunteers provides the best riding experience opportunity and the experience influences self-esteem, self-confidence, communication and interpersonal skills of the rider (Kersten and Thomas, 2000). Benda *et al.* (2003) described EAT as a physical therapy that uses the movements of a horse to improve posture, balance, and gross motor function. The positive effects are many and they are substantial.

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Communions of handicapped children or adults with horses are confirmed in all Hippotherapy programs all over the world (Hyatt and Sarah, 2009). In Therapeutic riding and Hippotherapy, horse-related exercises can be seen similar but they have fundamental differences in priorities and purposes.

3. RIDING FOR THE DISABLED (RD)

3.1 History of Riding for the Disabled

A literature of the ancient Greece recorded 「In the fourth century B.C., an injured soldier from a battle was cured by horse-riding. A horse has been used as a therapist from the ancient Greece and Hippocrates said "therapy method of horse riding is a rhythm of a horse" (Bliss, 1997). It is told that Horse riding was used to enhance mental strengths of terminally ill patients in early Greece (Bizub *et al.*, 2003). From that time, the term 'riding for the disabled (RD)' was firstly used in the early 20C by two British, Agnes Hunt and Miss Olive Sands.

In 1901, Hunt founded Ozwest orthopedics hospital and Suns started to provide horse riding to injured soldiers from world war 1. Hippotherapy was widely known since Liz Hartel who suffered poliomyelitis in 1943 won a silver medal at the Helsinki Olympics in 1952 (Crawley *et al.*, 1994).

Today, RD is popular in Europe, United States, South Africa, and Australia. Physical and mental effects of horse riding was described and recorded since the sixteen-hundreds and horse riding was used as a prescription for neuropathy as well as low morale (All *et al.*, 1999).

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Since then, British RD advisory committee which started with nine members is now become riding for the disabled association (RDA) which has 80 members. United States established a foothold by organizing NARHA that covers North America and Canada in 1969. Furthermore, interests in RD grew all over the world and consequently various associations have been founded for the development of RD such as German Hippotherapy Association in 1970 and Australian riding for the disabled in 1972.

NARHA provided safety precautions, training, and Hippotherapy instructor licenses. They installed high standard Hippotherapy centers and disseminated information in the past. Since initiation, horse riding has became more than just a mode of transportation and it has started to be recognized as a way to improve health and happiness of people with disabilities (NARHA, 1995).

Later, the Federation Riding for the Disabled International (FRDI) was founded in 1980 for mutual improvement and exchange of information and it has a regular membership of 31 nations and 49 organizations and associate members of 49 nations and 186 organizations. Federation Fiding for the Disabled International is striving for qualitative and quantitative development of riding for the disabled through a triennial international conference and informative publications.

3.2 Components of Riding for the Disabled

RD is a rehabilitation therapy program that provides various physical, psychological, and mental stability and pleasures to people with physical or mental disabilities through the exercise of horse riding (An *et al.*, 2007). RD is defined as a life-long sport as well as a therapy method that leads disabled people to a healthy social life and physical or mental recovery through the exercise of horse riding. Regardless of the degree of disability, everyone can experience the benefits.

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Interest in the use of animals are growing. RD is reported as a use of horse riding for posture, balance, and mobility improvement of a patient during building a clinical bond between a patient and a horse (All *et al.*, 1999). Moreover, the riding assists various fields such as treatment, education, sports and recreation (PATH *Intl.*, 2010).

Lim and Han (2004) reported that scoliokyphosis and spinal curvature fared better affer the horse riding (3 hours per one session, 16 weeks) for children with mental retardation. Bass *et al.* (2009) suggested that sensible susceptibility, social motive and distraction were diminished while placidity was improved after 12 weeks of horse riding for autistic children.

According to NARHA (2002), riding for the disabled categorizes based on the purpose of the client to Hippotherapy, Educational Riding, Recreational Riding, and Sports Riding (PATH *Intl.*, 2010) and it promotes physical, mental, and social therapeutic effects.

3.2.1 Hippotherapy

Hippotherapy means a passive horse riding as well as a therapy that utilizes a horse as a tool for physiotherapy, operation treatment. Hence, it is a branch of rehabilitation that focuses on physical function improvements of a rider by using movements of a horse. Hippotherapy is a neurophysiologic treatment of physiotherapy that provides direct three-dimensional stimulations from the horseback to a rider (AHA, 2005; Sager *et al.*, 2008; Schwesig *et al.*, 2009).

A rider's waist exercise which is similar to human gait rotates pelvis from front to back and side to side and the rotation creates kinetic effects. The facilitation of muscle nerve roots improves muscles that give better posture and trunk control (Song, 2003). Front stimulation enhances balance, proprioception of joints, sensory integration, and organs. Moreover, stamina and patience are developed through a continuous front muscle contraction as a rider tries to maintain a posture on the saddle. Also, the speed and stride of a

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horse and adjustments to ground alteration, gravity, centrifugal force, and centripetal force develop balance and flexibility.

Hence, Hippotherapy focuses on trunk stabilization, posture, and pelvis mobility that are required for gait and balance development (Meregillano, 2004). Unlike Therapeutic riding that mainly teaches riding posture and techniques, Hippotherapy utilizes the movement of a horse itself as a tool of the therapy. Therefore, it is based on the nerve system and sensory process instead of teaching particular riding skills. The base can be adapted to large range of daily activities.

Activities of a horse are utilized in a form of treatment to achieve physical, psychological, cognitive, behavioral, and communicational goals. Thus, Hippotherapy is a therapy using movements of a horse and it is not a way that a rider directly drives a horse. The therapy is conducted by a licensed instructor for RD. The experts process the therapy by integrating treatment principles created within the core competencies of their own field of specialized horse activities. Qualified physical therapists, operational therapists, speech therapists, or psychotherapists can administer therapy when they compete training and become licensed in RD.

3.2.2 Therapeutic Riding

The purpose of RD is to enhance riding skills. Also, RD helps users to develop self-confidence, self-esteem, spatial perception, balance, as well as sociality regardless of his/her disability (Freire and Bruna, 2008). Because a rider participates in a sports activity with able bodied people, he/she can boost confidence and morale and learn to control their own emotions. Furthermore, teamwork and spatial perception are also improved because of the use of harnesses. Thus, the emphasis is on the riding skills and the riding goal-setting. RD is a special training program that provides the riding skill lessons for clinical or creational personal goal achievements to disabled peoples.

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The riding skills also allow disabled peoples to learn balance, coordination, or agility that can be helpful in daily life. Therefore, horse riding was suggested as an empirical therapy for autistic children. In order to achieve these effects, a rider must learn how to balance on a saddle, communicate with a horse through reins, disperse own weight evenly to sit properly while a horse is walking.

Therapeutic riding is an activity that provides physical, psychological and social pleasures, hence it focuses on physical function, psychology and sociality improvements of disabled through the riding. Unlike hippotherapy, therapeutic riding teaches the manner of horse riding and techniques to a rider. A rider experiences challenges and sense of achievement and improves confidence, sociality, interpersonal and communication skills. Therapeutic riding is conducted by registered a RD instructor.

3.2.3 Sports Riding

One step forward from therapeutic riding, sports riding is a life-long sport that disabled can enjoy with non-disabled as a hobby and even participate in competitions. Horse riding makes a rider to continue muscular and balance exercise when a rider tries to maintain body balance from the rotating motion of a horse through hip and thigh. Because sport riding needs not only maintaining right posture but also relaxation of body, it is an appropriate sport for ordinary people as well as disabled. It is not just a hobby but high-skilled disabled can participate in competitions or games and it boosts confidence and sense of achievement of a rider. There are international contests such as the Paralympics and a world championship (An *et al.*, 2007).

3.2.4 Recreational/Leisure Riding

With proper help, people with physical, mental, or psychological disabilities can use horse activity for recreation or leisure. Recreational and Leisure riding focuses on providing

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fun and relaxation for additional therapy effects that enhance sociality, posture, mobility, and overall quality of life; all positive benefits.

A Hippotherapy instructor and a recreational therapist handle many of the program development responsibilities (NARHA, 2002). The purpose of recreational riding is to improve the physical state or daily activity of disabled peoples through riding techniques and knowledge for people with physical or psychological disabilities and it can lead to additional benefits such as refreshment, stress relief, communication skills and confidence enhancements (An *et al.*, 2007). Also, because disabled peoples are active as volunteers, people with severe disabilities can safely participate in activities because the type of disorders can vary, as can the categorization of participants, therefore, with similar disorders, it is important for effective lessons.

Horse riding therapy is known as RD, Rehabilitation riding, Hippotherapy, and Horse therapy but the largest international organization, Riding for the Disabled Association (RDA), uses the term 'riding for the disabled'. The term is a concept of 'recreation and sports oriented horse riding for people with disabilities' rather than a therapeutic series of events. In fact, riding for the disabled is conceptually closer to rehabilitation (physical, mental, social, economic, and career capacity recovery of people with physical disabilities through maximization of remaining abilities) than therapy.

3.3 Benefits of Riding for the Disabled

The values of riding for the disabled can be classifies into three categories: psychological, physical and social effects. The first is the psychological effect and it promotes motivation, judgment, concentration, sense of achievement, and independence for positive attitudes in daily life.

The second is the physical effect that assists the whole body exercise. This means that the physical effect through RD encourages people with infirm or deteriorated physical

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development to improve walking function, joint motion, sense of balance, muscular strength, patience, and muscle tone. The last is the social effect that enhances communication skills and social adaptability through relationships with an instructor and volunteers. More In summary, people with disabilities can benefit from the following:

Physical

- Effects of balance and strength
- Effects of coordination and faster reflexes
- Effects of muscular control
- Effects of postural control
- Decreased spasticity
- Improved range of motion of joints
- Stimulates sensory integration
- Improved gross and fine motor skills etc.

Psychotherapy

- Improved self-confidence
- Increased self-esteem and self-image
- Development of patience
- Emotional control and self-discipline
- Expansion of locus of control
- Improved risk-taking abilities
- Socialization and improved interpersonal skills
- Increased perception of quality of life
- Stress reduction etc.

Educational

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- Learning horseback riding knowledge and skills
- Learning safe behaviors for riding

RD critically affects many physical abilities of a human. This kind of adjustment brings physical, psychological, and educational effects. As a tool of the therapy, horse riding starts from the provision of sensorimotor experience of physical development, maintenance, rehabilitation, and improvement to disabled. The sensorimotor experience is an improvement of muscles through continuous adjustment of balance responses and responses to remain right posture in a relation to gait, speed, and direction of a horse (Mackinnon *et al.*, 1995). Because horse riding moves a body of a rider similar to human gait, a rider with physical disability experiences improvements in flexibility, balance, and strength and a rider with mental or emotional disabilities experiences improvements in confidence, patience, and self-esteem through a unique communion with a horse.

Hippotherapy improves spatial perception, balance, and communication skills and leads enhancements of physical functions such as sensitivity or sociality of people with many kinds of disabilities or disorders (Freire and Bruna, 2008). In addition, other effects of RD are muscle strengthening and relaxation, reduction of muscular spasm, increase of range of motion, and digestive capacity improvement. Generally, people with the following disabilities can participate in and experience the effects of RD. Individuals with the following disabilities commonly participate and benefit from equine assisted activities and therapies:

- Cerebral Palsy
- Visual Impairment
- Down Syndrome
- Intellectual Disability

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- Autism
- Multiple Sclerosis
- Spina Bifida
- Emotional Disabilities
- Brain Injuries
- Spinal Cord Injuries
- Amputations
- Learning Disabilities
- Attention Deficit Disorder

3.3.1 Cerebral Palsy

Among many disabilities, CP (a sort of brain lesions) has been continuously increased in the past 20 years. Its main causes are premature infants less than 34 weeks and low birth-weight infants less than 2.5kg but their survival rates are high because of medical developments (Vargus-Addams, 2005; Jane, 2008).

CP is one of the most common permanent disorders in children and it causes motor or posture functional disorders through non-progressive lesions in the central nervous system. Moreover, a patient experiences many difficulties in daily life because it may include behavior and cognitive disorders as well (Barlow *et al.*, 2007).

RD provides life-long sports and leisure opportunities that improve confidence, ambition, and sense of responsibility of teenagers with cerebral palsy through developments of cognitive ability. In addition, it promotes correct posture, balance, and flexibility for functional independence.

3.3.2 Visual Impairment

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Visual impairment is defined based on welfare, medical, or educational purposes but it normally refers to the inconvenience or impossibility of seeing due to damages in visual organs such as eyeballs, optic nerve, or the cerebrum nucleus (Jang *et al.*, 1998). The related effects are improvements to sensorimotor skills, independence, confidence, balance, and muscle tone.

3.3.3 Down Syndrome

Down syndrome, discovered by Langdon Down in 1866, is the most common genetic condition that provokes mental retardation. Down syndrome has Trisomy at the 21st chromosome arrangement. Down syndrome is the most common and identifiable disorder among intellectual disabilities.

Children with Down syndrome have physical activity restraints because of several additional disorders. First, 12~22% patients with Down syndrome include Atlanto-Axial Instability (AAI), hence they must take Atlantoaxial (the first and second neck vertebrae) prior to the exercise. Second, children with Down syndrome at growth phrase have mortality of 20~30% because of infections. Third, Down syndrome children may experience strabismus or cataract. Fourth, Down syndrome children have weak contractile forces. Consequently, they have large range of joint motion resulting high level of flexibility but they are easily tired because of the weak contractile forces (Jang *et al.*, 1998).

By conducting a program with considerations for the circumstances, RD can give enormous pleasure and satisfaction to people with Down syndrome and intellectual disabilities. Down syndrome children can experience the effects of RD such as improvements of sociality, self-esteem, coordination of eyes and hands, and muscle tone.

3.3.4 Intellectual Disability

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People who have conspicuously lower cognitive capacity and have difficulties to perform normal social behaviors are commonly called intellectual disability. If the symptom appears during the growth phrase (before the age of 18), it is diagnosed as an intellectual disability (behavior disorder classified table: DSM-Ⅳ, American Associated on Mental Deficiency, AAMD).

Intellectual disability means serious intellectual skill and conceptual, social, active related behavioral restraints. Intellectual disability can be improved by education and therapy but it is a permanent disorder which is caused by generic factors. Therefore, genetic factors or incomplete pregnancy causes roughly 4% of intellectual disabilities.

Sheill (1993) and Fine (2006) reported that continuous contact with horses promotes communication skill, sensory function, cognitive and reflective capacity improvements. McGibbon *et al.* (2009) and Shurtleff *et al.* (2009) demonstrated that horse riding affects the the development of coordination, balance, spasticity, and gross motor function as well. Horse riding that utilizes the movements of a horse makes a rider able use common muscles and joints. Furthermore, it solves the issue of a lack of exercise by helping to aid in the recovery of physical functions through nerve stimulation (Bertoti, 1988).

3.3.5 Autism

Autism is a developmental disability that causes defects in sociality, communication skill, and motor functionality (APA, 1994). Bass *et al.* (2009) suggested that AAA is beneficial to cure typical autism characteristics and RD, especially, is effective for improving social perception.

Autism appears among boys three times more than girls and it is a complex developmental disorder. In particular, it appears within 3 years from birth and it affects communication and interpersonal skills. Also, an autistic child experiences frail gross and fine motor skills, perception-motor, physical strength, or motor ability deficits as well as

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slow physical development. Studies on autism focus on neurobiology relations (Keller and Persico, 2003) but its cause is known for the problem in the cerebellum (Pierce and Courchesne, 2001).

Bass *et al.* (2009) stated that the cerebellum controls motor and social domains and suggested a possible correlation between the cerebellum and RD which requires motor educability, mobility adjustment and sociality.

3.3.6 Multiple Sclerosis

RD can be a beneficial exercise source that improves energy and muscle tone of people with multiple sclerosis within the limited range. This develops independence, confidence, and sociality of a rider.

3.3.7 Spina Bifida

Spina Bifida usually requires precautions and cautions to conduct Hippotherapy. RD can improve physical development of people with spina bifida but the matter of balance has to be checked carefully.

3.3.8 Emotional Disabilities

Emotional disability implies people with difficulties in social adjustment because of unstable emotions and feelings. To emphasize problems of emotion or feeling, emotional disability is also called affective disorder. It is called behavior disorder as well because patients experience difficulties to adjust society.

Children with emotional disabilities have weaker gross and fine motor activity and perception-motor ability than ordinary people. Patients who have perception-motor ability problems cannot clap, operate toys, and imitate (Auxter and Pyfer, 1985).

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RD can assist people with various emotional disabilities. It improves self-awareness, confidence, emotional bonding, and appropriate self-expression. Team activities and trusts are one of many beneficial activities that can help emotional and spiritual development.

3.3.9 Brain Injuries

RD programs usually change the behavior of a rider from inappropriate responses to intended responses. Movements of a horse lead to improvements of muscle tone and balance and horse riding techniques to enhancements that develop speech and short-term memory.

3.3.10 Learning Disabilities

People with learning disabilities do not have external disorder factors but they cannot do normal activities under certain circumstances because of nervous system disorders. People with learning disabilities can live and study normally because they have cognitive abilities. However, they have difficulties under certain situations or related to particular subjects.

Learning disabilities usually include lagging verbalism functions, partial memory blackouts, aphasia, stammering, impulsive actions, and frail physical abilities (Auxter and Pyfer, 1985). Many riders show sensory and motor capacity improvements after participating in RD. Symmetric and rhythmic movements of a horse decrease problems of children with learning disabilities through teamwork, body-awareness, and flexibility improvements. Additionally, symmetry muscles (Benda *et al.*, 2003), general motion development (Mackinnon, 1995), and linguistic motor control (Macauley *et al.* and Gutierrez, 2004) are considered direct physical benefits of RD.

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3.3.11 Attention Deficit Disorder

Attention deficit disorder implies the negligent state due to lack of attention that stayed longer than 6 months causing difficulties in study or social adjustments. Most of children with short attention include hyperactivity hence, attention deficit disorder is named to attention deficit hyperactivity disorder (ADHD) that includes hyperactivity, attention deficit, and impulsiveness (Schachar *et al.*, 1987; Polanczyk *et al.*, 2007).

Clements and Peters (1962) designated ADHD to minimal brain dysfunction in order to discriminate with the cerebrum damage. A rider with ADHD can experience motor response, and problem solving skill improvements though riding for the disable. A horse of RD plays an important role as a therapist.

RD is usually utilized for people with physical disabilities because it improves posture, equilibrium, left and right balance, and coordination. Movements of a horse provides proper tension and balance to a rider so, people with disabilities can experience mental, physical, and social effects from RD.

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4. UTILIZATION OF JEJU CROSSBRED HORSE

Recently, studies on the utilization of Jeju crossbred horse for RD has initiated. Studies for tertiary industries such as cosmetic products using horseflesh and mare milk are in progress as well. This study focuses on the utilization of Jeju crossbred horses for RD and the exercise physiology of a horse.

4.1 Jeju Crossbred Horses for Riding Horses

In recent years, the kinetic effect of riding and the endurance of Jeju crossbred horses have been highly rated for basal conditions for the riding horse in the riding horse qualification scale. According to the Rural Development Administration (2010), anaerobic threshold which is a representative measurement indicator of aerobic motor capacity improved by 25%, oxygen consumption per heart rate enhanced by 36%, and body fat percentage and abdominal obesity decreased in the study of riding effect of Jeju crossbred horses that have a minimum of 25 BMI. Furthermore, blood chemical value and cardio endurance per exercise intensity were suitable for the endurance riding and the excellence of endurance was proved as heart rates recovered to less than 64bpm after 10-minute rests.

The study of Oh *et al.* (2009) on the Jeju crossbred horses demonstrated the clear variations between the training degrees of kinematic variables during 2 strides of free walking. In addition, Kang *et al.* (2010) reported that the angle of joints affects the balance for maintaining a correct hand stamp according to the analysis of each rider's joint angles. The endurance capacity of Jeju crossbred horses has been verified at recent 40km, 60km, and 100km endurance riding competitions. The height of Jeju crossbred horses is a favorable condition for beginners or female riders.

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4.2 Jeju Crossbred Horses for Riding for the Disabled

The interests in Jeju crossbred horses are growing because the riding population increases rapidly and the abilities of Jeju horses are appreciated. The chest width of Jeju crossbred horse is approximately 140cm and the horse is also human-friendly.

Horses for RD must be meek and mild (NARHA, 2005). Selection of an ideal horse for RD is very important for safety, high quality clinical movements, and required lessons of a rider (Kang, 2009; PATH *Intl.*, 2010). Balance disposition, quality and characteristics of gaits are important criteria of the selection of a horse for RD in any rehabilitation programs (Engel, 1992; Moore, 1992; Wiger, 1992). A suitable horse for RD has an appearance of small height with large chest width. Matsuura *et al.* (2008) stated that the body type of a horse affects a movement of a rider in the study on the horse assessment for RD. Furthermore, the study argued that a shorter horse provides stability to a rider and the height provides beneficial environment to side-walkers as well (people protects a patient from the side of a horse). In addition, it also reported that a wide horse is advantageous to a rider who has a hard time to maintain balance on the horse.

Jeju crossbred horse that has a small height with large chest width reduces anxiety and enhances confidence of a rider through its unique physical features (Matsuura *et al.*, 2008). Jeju crossbred horse has approximately 140cm height and features large chest width. This appearance is very suitable for RD. Therefore, behavior characteristic analysis and disposition study of Jeju crossbred horse that has a suitable appearance should be continued.

4.3 Selection of a Horse for Riding for the Disabled

RD focuses on the utilization of a horse-centered activity in order to derive cognitive, physical, mental, emotional, and social happiness of disabled peoples. Therapeutic riding teaches riding skills to disabled peoples. RD assists a child or an adult who has a particular cognitive, physical, mental, or emotional problem.

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The selection of an ideal therapy horse is important for safety, qualitative treatments and the needs of a rider. To achieve this, health, appearance, gait and disposition are considered significant factors in a horse selection for the therapeutic riding program (Engel, 1992; Moore, 1992; Wiger, 1992).

Recently, interest in Therapeutic riding such as RD or Hippotherapy are growing (Matsuura *et al.*, 2008). According to the official manual of RDA (1990), good-nature, composure, and goodness are sine qua non of a horse for disabled peoples. If the disposition of a horse is appropriate, its structure (wide or narrow, short or long gait, flourishing or sluggish) becomes an important factor.

A qualified Therapeutic riding instructor is obliged to assign a proper horse to a rider because he/she has an overall responsibility for the program procedure and the horse. Instructors have to consider a state and a purpose of a rider when they choose a horse (Matsuura *et al.* 2008). Generally, the chest-width of a horse is the most common indicator to classify body types of horses.

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CHAPTER 3

EFFECTS OF COOLDOWN METHODS AND DURATIONS ON EQUINE PHYSILOLGICAL TRAITS FOLLOWING HIGH-INTENSITY EXERCISE

ABSTRACT

This study was initiated to investigate the physiological effects of cooldown methods and durations on recovery following high-intensity exercise (3,000 m, 10 m/s) of 25 Jeju crossbred horses. HR was measured and blood samples were collected for glucose, blood lactate concentration, PCV, TP, and Hb analysis. The cooldown methods employed involved walk rest (WR) or trot rest (TR), and the durations compared were 15, 30, and 60 min.

A passive rest group (PR) was used as a control. According to the analysis, HR decreased after a 15 minutes rest in all groups, showing a faster recovery in the active rest groups, WR and TR, than in the PR group after 30 minutes ($p < 0.05$). In the case of glucose, the decrease was faster in the WR15 group then the WR30 group suggesting that active rest is more effective in controlling this parameter ($p < 0.05$). As for lactate, TR15 showed a 75% decrease which was a significantly positive effect. There were no differences in PCV between the groups.

Horses in the PR group showed faster recovery for TP and Hb than those in the active rest groups ($p < 0.05$), while lactate removal was faster in active rest groups than in the PR

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group, suggesting that the cooldown process plays an important role in recovery. This study showed that the cooldown method and duration employed after high-intensity exercise of horses makes a difference with regard to their physiological status. Also, 15 minutes rest after exercise appears to be the most significant period in terms of duration.

In conclusion, active rest was necessary for rapid recovery and a 15 to 30 minutes cooldown walk or trot was beneficial to the horses in which physical fatigue had accumulated. In particular, the active exercise method of trotting was found to be more effective than walking to remove lactate. In addition, the cooldown duration is expected to be more effective when adjusted according to the individual training state of the horse.

Keywords: Cooldown, High-intensity exercise, Jeju crossbred horse, Physiological traits

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INTRODUCTION

Cooldown exercise helps to keep the elevated body temperature after exercise to normal levels as well as to remove efficiently lactic acid accumulated in the body (Gisolfi, 1966). Exercise is closely related to energy of aerobic and anaerobic metabolism (Hinchcliff *et al.*, 2002). There is a strong relationship between exercise performance and lactate-related variations in horses (Piccione *et al.*, 2010).

Since Horse's heart rate is practically the best means of evaluating the horse's physical condition, understanding of horse's heart beat during the training and recovery stage is useful in evaluating the enhancement of fitness of a horse resulted by training and its training condition (Ferraz *et al.*, 2008).

During the aerobic exercise, glucose is decomposed by the glycolysis process for producing energy. However, lack of oxygen during anaerobic glycolysis can turn glucose into pyruvic acid (Guyton, 1981). This pyruvic acid, in turn, produces lactic acid under the condition of insufficient oxygen, or is decomposed through the aerobic process when provided with sufficient oxygen.

Accumulated lactic acid acidifies body tissues and blood causing physical fatigue and deterioration of exercise performance. Medium level exercise in terms of type and intensity does not cause a problem (Karlsson et al, 1972). However, during high intense exercises the quantity of lactic acid increases sharply (Lindinger, 2005).

One way of eliminating the accumulated lactic acid is to recycle it as an energy source by inhaling sufficient oxygen through aerobic system (Hodgson and Rose, 1994). In addition, evaluation of the horse's physical training condition can be done by measuring frequently the concentration rate of PCV (Nostell et al, 2006), TP (Hinchcliff *et al.*, 2002), Hb (Piccione *et al.*, 2010), which indicate the horse's oxygen-carrying capacity and its level of dehydration

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and anemia. With a recent sharp increase in horse riding population, it is regarded as very important to secure the recovery of horses after exercise.

Horse riding can be obtained the best effect of exercise when oneness of horse and rider is maintained (Terada *et al.*, 2006; Kang *et al.*, 2010). Horse and rider should maintain the best conditions during horse riding. Therefore, it is necessary for horse to recover the exhausted condition from exercise.

Typically, blood lactate is an indication of anaerobic metabolism and can be an important indicator of fatigue (Costill *et al.*, 1971; Eto *et al.*, 2004). The result, lactate production, accumulation, and removal are important metabolic data relevant to the interpretation of results obtained from the measurement of blood lactate concentration (Gondim *et al.*, 2007). Therefore, the purpose of this study was to investigate the physiological effects of cooldown methods and durations after exercise in Jeju crossbred horses.

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MATERIALS AND METHODS

Animals

This study was approved by the Animal Ethics Committee of Jeju National University, Korea. The horses evaluated were 25 clinically healthy Jeju crossbred horses (Jeju native x Thoroughbred), 2 males and 23 females, 5.5 ± 1.8 yr of age, weighing 339 ± 26.8 kg, which had not been exercised for at least six mo prior to the study.

Experimental design

This study was conducted to determine the effects on recovery after high-intensity exercise according to cooldown method and duration employed. Horses were ridden by six male riders (age 41.8 ± 13.2 yr; height 172 ± 6 cm; weight 73.5 ± 7.4 kg) with riding instructor certification and more than five yr of riding experience .

The track used had a circumference of 600 m and each horse completed a 1,200 m trot warm-up prior to testing after which each horse was ridden 3,000 m at a gallop (10.0 m/s). The horses were divided into five groups as follows: passive rest (standing tied rest) immediately after exercise (PR), rest after 15 minutes walk (WR15), rest after 30 minutes walk (WR30), rest after 15 minutes trot (TR15), and rest after 30 minutes trot (TR30).

Heart rate (HR) and blood samples were collected from all groups before exercise (BE), immediately after exercise (AE), and 15, 30, and 60 minutes during recovery. Blood samples were analyzed for glucose, lactate, PCV, TP, and Hb. The 1,200 m and 3,000 m times were recorded with a stop-watch by the same observer. The cooldown walk or trot after exercise was performed on a treadmill.

After exercise and cool down all horses were released to pastures to rest. In this study, criteria of comparison employed to measure the change in recovery rate are fixed to 100%,

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which is the condition right after exercise. Figure 3.1 shows the recovery rate according to the type and time of rest and all figures are converted into a percentage.

Heart rate measurements and blood analysis

HR was measured before and after exercise with a T31 Polar transmitter (Polar Equine, Finland). Resting heart rate was measured when horses were resting quietly in the pasture. Venous blood (5 ml) was taken from the jugular vein with a 21-gauge needle using Vacutainer® collection tubes containing lithium heparin.

All blood samples were collected by the same veterinarian for reduce experimental error. Blood samples were analyzed immediately for whole blood lactate concentration using an LT-1710 L-Pro lactate analyzer (ARKRAY Inc., JAPAN) and glucose concentration was assessed using the Accu-Chek Go system (Roche, Germany).

Blood samples for measurement of PCV, TP, and Hb were stored in ice-box immediately after collection. PCV was analyzed by a capillary micro centrifuge(12,000 rpm, 5 minutes). Total protein was measured with a refractometer (Atago SPR-NE, Atago Co LTD, Japan).

The Hb concentration is measured with commercial hemoglobin kit (Van Kampan-Zijlstra's Cyanmet hemoglobin method, ASAN, Japan). The percent transmission at 540 nm is recorded and compared with the prepared standard curve of cyanmet hemoglobin.

Statistical analysis

Data were analyzed using an analysis of covariance (ANOVA) for repeated measures with times (15, 30, and 60 minutes) and cooldown methods (PR, WR, and TR). All values were reported as means ± SD using SAS program (SAS Institute Inc. *ver* 8, Cary, USA) and considered significant at $p < 0.05$.

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RESULTS

Exercise performance

In this study, the mean speeds of the horses during exercise were 3.4 ± 0.41 m/s and 10.0 ± 0.43 m/s for the 1,200 m warm-up trot and 3,000 m exercise gallop, respectively. This study was initiated to investigate the physiological effects of cooldown methods and durations on recovery in the horse after high-intensity exercise. HR and blood were evaluated for PCV, TP, and Hb before and after high-intensity exercise.

The cooldown methods employed included walking or trotting after exercise for durations of 15, 30, or 60 minutes. Rest without walking or trotting was used as a control with standing tied.

Heart rate

Heart rate after high-intensity exercise was highest immediately after exercise and gradually decreased in a time-dependent manner ($p < 0.001$). Heart rate values for WR 15, WR 30, and TR 15 groups recovered to the level of BE after 30 minutes of rest, while the PR and TR 30 groups took 60 minutes to recover (Figure 3.1A). All groups showed complete recovery of HR at 60 minutes post-exercise (Table 3.1).

Blood glucose level

Differences in blood glucose levels among the groups are presented in Figure 3.1B and Table 3.2. The WR groups had lower blood glucose levels than the PR

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group, while the TR groups showed a slight increase in glucose 15 minutes after exercise ($p < 0.001$) in recovery rate (Figure 3.1B). The same tendency was observed at 30 minutes after exercise. All groups had similar blood glucose levels at 60 minutes after exercise. The WR groups showed the fastest recovery of blood glucose to BE among all the groups.

Lactate

There were significant differences in the concentrations of blood lactate during the resting period among the groups ($p < 0.001$). WR and TR groups had higher lactate removal rates than the PR group (Figure 3.1C and Table 3.3). In particular, the TR 15 group had the highest lactate removal rate at 15 minutes after exercise showing a greater ability to remove lactate during the early post-exercise period than the other groups ($p < 0.001$).

Blood lactate concentrations of the WR 30 and TR 30 groups recovered to BE levels after a 30 minutes rest. The PR group, however, showed the slowest recovery rate of blood lactate and had lower lactate removal ability than the WR or TR groups, suggesting that active recovery is more effective than passive recovery in the removal of lactate from the blood.

Packed cell volume

PCV is the proportion of blood volume occupied by red blood cells and is used to assess dehydration, anemia, and oxygen delivery capability. Table 3.4 shows the level of blood PCV for the cooldown methods at different time points.

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The WR15 group had a higher PCV than the PR group 15 minutes after exercise ($p < 0.001$), while the TR 15 group had a lower value than the PR group at the same time point (Figure 3.1D). Blood PCV levels recovered to BE levels after a 30 min rest and there was no difference among the cooldown methods after 60 minutes of rest (Table 3.4).

Total protein

TP of blood was also measured as an aid in estimating the hydration status. Table 3.5 shows the level of blood TP for the cooldown methods at the different time points. The WR15 group had the fastest recovery rate of blood TP at 15 minutes rest.

Hemoglobin

Differences in Hb levels among the groups are presented in Table 3.6 to confirm the effects of the cooldown methods at the different time points. Hb levels at 15 minutes after exercise were 14.58 g/dl in the PR group, 25.18 g/dl in the WR group, and 29.98 g/dl in the TR group. Hb values in the WR and TR groups were slightly increased at 15 minutes after exercise and then decreased gradually depending on the rest period.

The PR group had the same Hb level during the resting period, suggesting that passive recovery was more effective than active recovery in Hb removal.

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Table 3.1. Effects of cooldown methods and duration on heart rate (Means ± SD) of horses

Treatment[1]	Measurement Time				Significance
	AE	15 min	30 min	60 min	
PR	128^{ax} ± 7	75^{ay} ± 5	56^{by} ± 3	45^{az} ± 3	***
WR15	133^{ax} ± 7	75^{ay} ± 5	56^{bz} ± 3	48^{az} ± 3	***
WR30	120^{ax} ± 7	-	57^{by} ± 3	42^{ay} ± 3	***
TR15	143^{ax} ± 8	84^{ay} ± 5	59^{bz} ± 3	47^{az} ± 3	***
TR30	131^{ax} ± 7	-	73^{ay} ± 3	52^{az} ± 3	***
Significance	NS	NS	**	NS	

Levels of significance: NS, not significant; ** $P<0.01$;*** $p < 0.001$.

[A,b] Means with different superscripts in the same column significantly differ ($p < 0.05$).

[X-z] Means with different superscripts in the same row significantly differ ($p < 0.05$).

[1] PR, passive rest; WR, walk rest; TR, trot rest; AE, immediately after exercise.

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Table 3.2. Effects of cooldown methods and duration on blood glucose concentration (Means ± SD) of horses

	Measurement Time				
Treatment[1]	AE	15 min	30 min	60 min	Significance
PR	$102.7^{bx} \pm 6.9$	$97.6^{bxy} \pm 5.7$	$89.0^{ayz} \pm 4.7$	$76.4^{bz} \pm 4.5$	***
WR15	$122.8^{ax} \pm 5.6$	$99.2^{aby} \pm 4.7$	$90.0^{az} \pm 3.8$	$89.8^{az} \pm 3.6$	***
WR30	$125.6^{ax} \pm 5.6$	-	$86.0^{ay} \pm 3.8$	$90.3^{ay} \pm 3.7$	***
TR15	$116.4^{abx} \pm 7.5$	$114.4^{ax} \pm 6.3$	$99.1^{ay} \pm 5.2$	$86.9^{aby} \pm 4.9$	***
TR30	$105.2^{bx} \pm 5.8$	-	$94.8^{ay} \pm 3.9$	$73.2^{bz} \pm 3.8$	***
Significance	†	*	NS	*	

Levels of significance: NS, not significant; ** *P*<0.01;****p* < 0.001.

[A,b] Means with different superscripts in the same column significantly differ ($p < 0.05$).

[X-z] Means with different superscripts in the same row significantly differ ($p < 0.05$).

[1] PR, passive rest; WR, walk rest; TR, trot rest; AE, immediately after exercise.

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Table 3.3. Effects of cooldown methods and duration on blood lactate concentration (Means ± SD) of horses

Treatment[1]	Measurement Time				Significance
	AE	15 min	30 min	60 min	
PR	$11.10^{ax}\pm1.12$	$6.20^{ay}\pm0.92$	$4.02^{ayz}\pm0.54$	$2.16^{az}\pm0.32$	***
WR15	$8.08^{ax}\pm1.13$	$3.60^{aby}\pm0.93$	$2.49^{aby}\pm0.54$	$1.70^{ay}\pm0.32$	***
WR30	$7.58^{ax}\pm1.12$	-	$1.20^{by}\pm0.54$	$1.16^{ay}\pm0.32$	***
TR15	$10.76^{ax}\pm1.15$	$2.60^{by}\pm0.95$	$2.27^{byz}\pm0.55$	$1.26^{az}\pm0.33$	***
TR30	$10.91^{ax}\pm1.14$	-	$1.75^{by}\pm0.55$	$1.56^{ay}\pm0.32$	***
Significance	NS	†	*	NS	

Levels of significance: NS, not significant; ** *P*<0.01;****p* < 0.001.

[A,b] Means with different superscripts in the same column significantly differ ($p < 0.05$).

[X-z] Means with different superscripts in the same row significantly differ ($p < 0.05$).

[1] PR, passive rest; WR, walk rest; TR, trot rest; AE, immediately after exercise.

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Table 3.4. Effects of cooldown methods and duration on blood PCV (Means ± SD) of horses

Treatment[1]	Measurement Time				Significance
	AE	15 min	30 min	60 min	
PR	52.3^{ax}±3.9	40.9^{by}±3.7	35.9^{by}±3.4	44.2^{ay}±3.8	***
WR15	56.9^{ax}±3.6	51.6^{axy}±3.4	44.3^{abyz}±3.1	35.0^{az}±3.5	**
WR30	47.4^{ax}±3.0	-	39.5^{by}±2.6	40.7^{ay}±2.9	**
TR15	56.1^{ax}±3.2	40.8^{by}±3.0	38.6^{by}±2.8	42.7^{ay}±3.1	***
TR30	52.6^{ax}±3.1	-	47.6^{axy}±2.7	43.0^{ay}±3.0	*
Significance	NS	**	*	NS	

Levels of significance: NS, not significant; ** *P*<0.01;****p* < 0.001.

[A,b] Means with different superscripts in the same column significantly differ ($p < 0.05$).

[X-z] Means with different superscripts in the same row significantly differ ($p < 0.05$).

[1] PR, passive rest; WR, walk rest; TR, trot rest; AE, immediately after exercise.

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Table 3.5. Effects of cooldown methods and duration on blood TP concentration (Means ± SD) of horses

Treatment[1]	Measurement Time AE	15 min	30 min	60 min	Significance
PR	9.13^{ax}±0.19	8.39^{ay}±0.19	7.79^{ayz}±0.19	7.66^{az}±0.19	***
WR15	7.95^{bcx}±0.21	7.60^{bx}±0.20	7.33^{abx}±0.20	7.36^{ax}±0.21	NS
WR30	7.85^{cx}±0.19	-	7.19^{by}±0.18	7.51^{axy}±0.19	†
TR15	8.41^{bx}±0.19	8.02^{abxy}±0.18	7.83^{axy}±0.18	7.72^{ayz}±0.18	*
TR30	8.18^{bcx}±0.20	-	7.57^{aby}±0.19	7.67^{ay}±0.20	***
Significance	***	***	†	NS	

Levels of significance: NS, not significant; ** P<0.01;***p < 0.001.

A,b Means with different superscripts in the same column significantly differ (p < 0.05).

X-z Means with different superscripts in the same row significantly differ (p < 0.05).

1 PR, passive rest; WR, walk rest; TR, trot rest; AE, immediately after exercise.

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Table 3.6. Effects of cooldown methods and duration on blood Hb concentration (Means ± SD) of horses

Treatment[1]	Measurement Time AE	15 min	30 min	60 min	Significance
PR	24.2^{bx}±1.8	13.2^{cy}±1.3	11.4^{by}±1.9	13.6^{by}±1.5	***
WR15	21.3^{bx}±1.6	25.2^{bx}±1.2	24.3^{ax}±1.7	25.1^{ax}±1.3	***
WR30	19.5^{bcx}±1.7	-	14.0^{byz}±1.8	14.7^{by}±1.4	***
TR15	29.6^{ax}±1.6	30.1^{ax}±1.2	28.0^{axy}±1.7	27.8^{ax}±1.3	***
TR30	16.0^{cy}±1.6	-	27.2^{ax}±1.7	13.7^{by}±1.3	***
Significance	***	***	***	***	

Levels of significance: NS, not significant; ** $P<0.01$;*** $p < 0.001$.

[A,b] Means with different superscripts in the same column significantly differ ($p < 0.05$).

[X-z] Means with different superscripts in the same row significantly differ ($p < 0.05$).

[1] PR, passive rest; WR, walk rest; TR, trot rest; AE, immediately after exercise.

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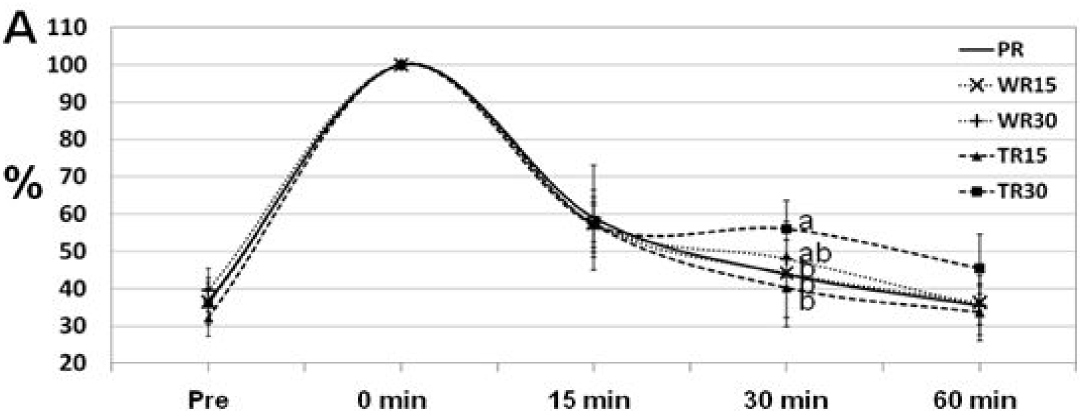

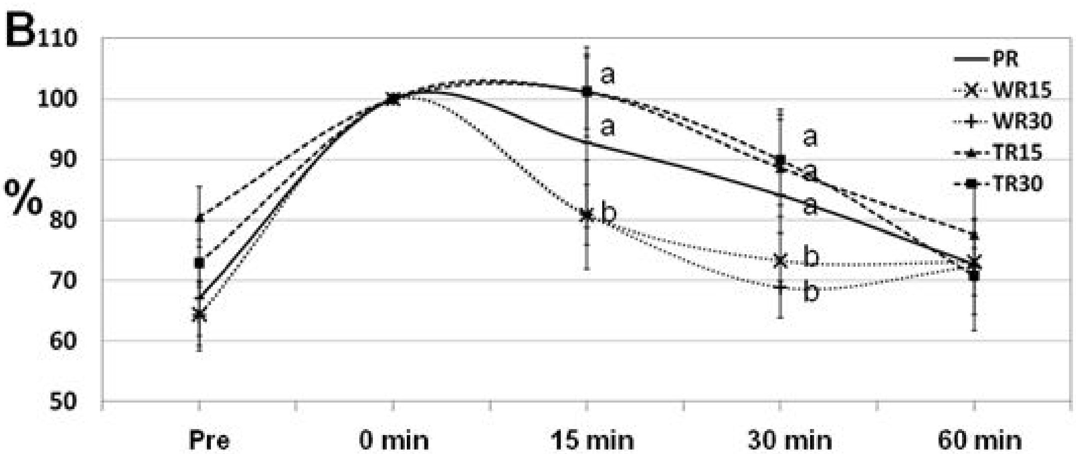

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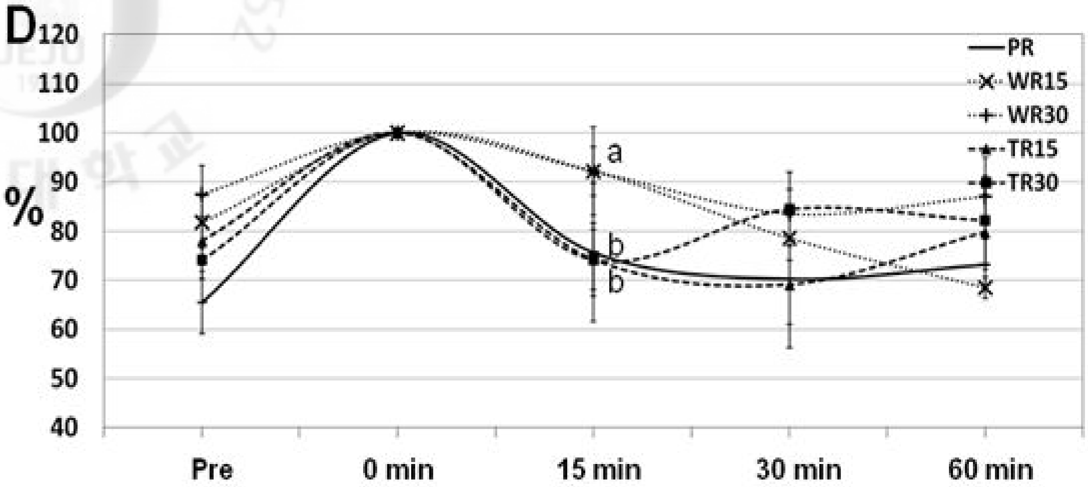

Figure 3.1. Changes of physiological parameters of horses during recovery stage. A, heart rate; B, glucose concentration; C, lactate concentration; D, PCV. A-c Means with different superscripts significantly differ (p < 0.05).

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DISCUSSION AND CONCLUSIONS

The objective of the cooldown period is to progressively reduce exercise intensity allowing for a gradual redistribution of blood flow, enhanced lactate removal from muscles, and the reduction of body heat through convection and evaporation (Clayton, 1991). A proper warm-up before exercise and cooldown afterwards is necessary for both humans and horses. The mean speeds of the horses recorded in this study were 3.4 ± 0.41 m/s for 1,200 m at a trot for warm-up and 10.0 ± 0.43 m/s for 3,000 m at a gallop for exercise.

The comparative results of resting on HR after exercise showed that there were no different among the groups. Decreasing rates after a 15 minutes rest in the PR, WR, and TR groups of 40.9%, 42.5%, 42.8%, respectively were in contrast to the expected result that the heart rate of the passive group would decrease differently compared to the active groups. The HR of a horse in stable condition is typically 28-40 bpm; however, the rate could be affected by several environmental factors.

For this experiment, the heart rate of horses at rest ranged from 44-49 bpm and the rate AE increased to 121-140 bpm. The difference in initial HR was attributed to environmental effects, riders, experimental assistants, and apparatus used in conjunction with the experiment. Upon comparing among groups recovery rate of blood glucose concentrations, the fastest decreasing rate occurred after a 15 minutes rest in the WR15 group which continued to decrease at 30 minutes rest. The WR15 group (26.7%) and WR30 group (31.2%) decreased significantly compared to the PR group (15.9%) (Figure 3.2B). It is suggested that the glucose level in the active group at low intensity is the result of quick recovery by anaerobic exercise.

The heart rate (170-180 bpm) of a race horse indicates that anaerobic metabolism occurs greatly during exercise due to the significant increase in lactate concentration to

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threshold levels and the onset of blood lactate accumulation after anaerobic exercise (Gondim *et al.*, 2007; Ferraz *et al.*, 2008). Many previous studies have evaluated changes in anaerobic metabolic physiological responses of the horse (Davie and Evans, 2000; Eto *et al.*, 2004; Pösö, 2002; Ferraz *et al.*, 2007, 2008; Piccione *et al.*, 2010). Most of these studies concerned lactate. In our study, changes in blood lactate concentrations were significant depending on the rest and exercise periods ($p < 0.001$).

A fast recovery rate to steady-state BE was observed in the WR15 group after a 15 minutes rest following exercise (Figure 3.1C). The PR group, however, had a high blood lactate concentration level despite a 30 minutes rest, indicating a much slower recovery rate compared to the other groups. Onset of blood lactate accumulation regarded as 4 mmol/L in sports medicine (Kindermann *et al.*,1979; Sjodin and Jacobs, 1981; Yoshida, 1984) has been used as an appropriate criterion for race horses (Gondim *et al.*,2007; Lindner *et al.*, 2009), as well as aerobic exercise and endurance exercise capacity (Piccione *et al.*, 2010).

Our results indicated that the PR group required a longer rest compared to the cooldown groups because it had a high lactate level (2.16 ± 1.01 mmol/L) after a 60 minutes rest whereas the lactate concentration level recovered to the threshold of < 4 mmol after 15 minutes of active cooldown. This result was attributed to the positive effects of cooldown exercise. Piccione *et al.* (2010) reported on a trot group with a very low lactate accumulation level after exercise and no significant difference after a 30 minutes rest. However, comparing this study to other overall results is not appropriate because the lactate concentration following aerobic exercise of 4 mmol/L was accumulated after exercise.

When a horse has intensive training, it requires a great deal of oxygen, and blood stored in the spleen is released to meet the increased oxygen demand. Therefore, PCV or Hb measurements can be used to determine oxygen delivery capabilities. This study showed that PCV recovered to the BE condition after a 15 minutes rest for the PR and TR15 groups, and all groups recovered close to the BE condition after a 30 minutes rest. Evaluation of the TP

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recovery rate showed a decrease from the maximum state after intensive training by resting method (PR group 8.7%, WR15 group 5.5%, and TR15 group 4.1% after 15 min rest). Also, a reduction in Hb in the PR group after a 15 minutes rest indicated a quick recovery.

Our study shows that when it comes to the level of glucose, PCV, TP, and Hb before exercise, there are differences among the groups. However these differences among groups before exercise have little importance, since the purpose of our experiment is to compare the changes according to type of rest with criteria of comparison for recovery rate marked as 100%, which reflect the condition right after exercise.

When compared between groups recovery rate, analysis of PCV, TP, and Hb showed the fastest recovery following a passive cooldown compared to active cooldown. This result may be related to the fact that with a passive cooldown measurements drop quickly because blood which was released to move large amounts of oxygen during exercise returns back to the spleen, while active cooldown requires a continuous supply of oxygen which in turn increases recovery time.

The purpose of cooldown exercise is to restore exercise performance by eliminating accumulated lactic acid, and this can be quickly achieved by reusing lactic acid as aerobic metabolism energy. The importance of cooldown exercise is an essential part to riding horses as well as racehorses. Racehorses and riding horses are very different in exercise types. Racehorses are galloping for a short time and resting longer than riding horses. On the other hand, riding horses are very riding horses should combind aerobic exercise with anaerobic exercise. The riding horses attended endurance performance (40km, 80km, and 100km) are should maintain the condition literate running, trotting, and walking during exercise. Thus, it is important to recover body condition as soon as possible.

In conclusion, this study shows that for the 15 minutes cooldown exercise group in the TR15 group, HR, lactic acid and PCV was recovered most rapidly, whereas among 30 minutes cooldown exercise groups, recovery of glucose, lactate, PCV was quickest in the

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WR groups. However, it is worth noting that enabling the horse to return sooner to competition without any impact of the prior exercise bout.

In this study, as to 15 minutes cooldown exercise groups, level of lactic acid as indicator of fatigue substance was recovered to 75%, 58%, 45.3% respectively in TR15, WR15 and R15 group, which means that recovery was efficiently achieved in active groups than passive groups. In particular, the TR group marked the raspiest recovery rate. The level of glucose and total protein declined rather slowly but stayed within the normal range, thus making elimination rate of lactic acid a critical factor. Therefore, it is suggested that the most appropriate resting way and time after anaerobic metabolism exercise is moderate intensity exercise, for example, 15 minutes of TR group. It will be meaningful when studies on manners (modes) and durations of rest are performed to recover exhausted horse from various activities.

The results of this study can be used as a basis for equestrians and riding instructors to design appropriate cooldown programs for horses following training and exercise sessions. Also, if adjustment to the period and method of cooldown are made based upon the training state of the horse, the results may be better with regard to the effect on recovery.

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CHAPTER 4

CHANGES IN PHYSILOLGICAL PARAMETERS ACCORDING TO SWIMMING TRAINING DURATION IN JEJU CROSSBRED HORSES

ABSTRACT

The changes in physiological parameters according to swim exercise duration were examined in five females well-trained Jeju crossbred horses. The horses were performed with swim exercise for 10 minutes (60.0 m/ min) once a day for 14 days. The horses had riding experience more than three years without swimming training experience. Physiological characteristics and hematic parameters were measured before swimming, immediately after swimming, and after a 10 minutes rest at first day (D_0), 7 days (D_7), and 14 days (D_{14}) of training.

After 14 days of swimming training, heart rate ($p < 0.05$), blood glucose concentration ($p < 0.05$), lactate concentration ($p < 0.001$), PCV ($p < 0.01$), and Hb ($p < 0.01$) measured immediately after swimming and after 10 minutes rest showed significant lower values than those of D_0. In particular, the lactate concentrations at D_0, D_7, and D_{14} immediately after exercise were 13.03±3.17, 6.40±2.91, and 4.66±2.37 mmol/L, respectively. In D7, PCV and Hb maintain the normal range in all sessions and there was no anemia or dehydration. TP was also maintains the normal range in all sessions.

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The results illustrate the benefits of swim training for riding horses and the need for the establishment of swimming routines of appropriate duration and intensity to maximize the advantages of swimming training.

Key words*:* Equine, Physiological parameters, Swimming Training, Jeju crossbred horese

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INTRODUCTION

Swimming is a well established method amongst trainers and owners, often used as a means of conditioning and rehabilitating horses. Most importantly, it provides a low risk of injury as the horse is not subjected to the pounding that track or field work can have on the joint. Swimming has also been found to be highly effective for treating horse diseases such as arthritis and tendonitis.

As a form of exercise, swimming is used with horses as a part of their training regimen, particularly when lameness exists (Thomas *et al.*, 1980). In addition to building basic muscle tone, it provides exercise, promotes the development of underutilized muscles, and expands and strengthens the heart and lungs. Water power, buoyancy, and water resistance influence the effects of swim training.

This type of training provides a considerable amount of exercise in a short amount of time as a result of the increased intensity and decreased impact on the legs (Waran, 2002). Also, water power develops pectoral muscles by enhancing breathing and increasing lung capacity (Pluim *et al.*, 2000; Fagard, 2003). Moreover, the power of pushing through water resistance builds up olfactory groove muscles, as every muscle of the body is used during active propelling exercise. Therefore, due to its effects on enhancing heart and lung function, and physical fitness in general, propulsion swim training is frequently utilized with horses to increase their endurance (Davie *et al.*, 2008).

Prior studies have concentrated on how swimming training affects the equine cardiovascular and respiratory systems (Asheim *et al.*, 1970; Misumi *et al.*, 1994; Jones *et al.*, 2002). Research in both humans and horses supports the existence of a relationship between left ventricular mass and maximal oxygen uptake. Equine studies using echocardiography also show a correlation between heart score and maximal oxygen uptake (Young *et al.*,

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2002). Swimming is an excellent exercise for enhancing the endurance of racehorses rather than addressing slow twitch muscle fibers.

Previous studies have investigated the effectiveness of a swimming exercise test for evaluating changes in performance measures, skeletal muscle composition (Misumi *et al.*, 1994, 1995), and respiratory function (Hobo *et al.*, 1998). However, previous studies, have not established the physiological benefits of swim training for horses; therefore, the aim of this study was to examine the effect of swimming training duration on physiological characteristics in Jeju crossbred horses.

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MATERIALS AND METHODS

Animals

A total of five Jeju crossbred horses (Jeju native x Thoroughbred) from riding centers on Jeju island were used for this study. The horses participated five females, weighing 318±18.5 kg with a mean age of 6.6±1.3 years. The horses had riding experience more than three years. However, they have never tried swimming training. All horses were clinically healthy prior to the swimming experience. This study was approved by the Animal Ethics Committee of Jeju National University, Korea.

Experimental design

This study was performed to determine effects on physiological variables according to swimming training duration. The training track used had a circumference of 30 m, a depth of 1.8 m and a width of 3 m. Training was performed for 10 min once a day for 14 days. Each horse completed 20 laps (60.0 m/ min) for swimming training (Figure 4.1).

The swimming training durations evaluated were: first day (D_0), 7 days (D_7), and 14 days (D_{14}) of training. Physiological characteristics, blood glucose, lactate concentration, PCV, TP, and Hb) were measured before swimming, immediately after swimming, and after a 10 minutes rest.

Prior studies, as to 15 minutes cooldown exercise groups, level of lactic acid as indicator of fatigue substance was recovered to 75%, 58%, 45.3% respectively in TR15, WR15 and R15 group, which means that recovery was efficiently achieved in active groups than passive groups (Kang *et al.*, 2011). Therefore, the rest period consisted of trotting on a treadmill.

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Period 1	Period 2		Period 3	
Measurement of horses	Swimming Training For 7days (10 min once a day)	Measurement of horses	Swimming Training For 7days (10 min once a day)	Measurement of horses
D_0	↔ 20 laps (60.0m/ min)	D_7	↔ 20 laps (60.0m/ min)	D_{14}

Figure 4.1. Diagram of experimental design

Heart rate (HR) measurements and blood analysis

HR was also measured before swimming, immediately after swimming, and after a 10 min rest with a T31 Polar transmitter (Polar Equine, Finland). Blood samples were taken from the jugular vein with a 21-gauge needle using Vacutainer® collection tubes.

Blood lactate concentrations were analyzed using an LT-1710 L-Pro lactate analyzer (ARKRAY Inc., JAPAN) and glucose concentrations were calculated using the Accu-Chek Go system (Roche, Germany). PCV, TP, and Hb were analyzed at the clinicopathologic laboratory of the veterinary teaching hospital at Jeju National University.

Statistical analysis

Data were analyzed using a two-way analysis of variance (ANOVA) for repeated measures with points before swim, after swim, and 10 min after rest at training periods D_0, D_7, and D_{14}. All data is reported as means ± SD with a significance level of $p < 0.05$ using SAS program (SAS Institute Inc. *ver* 8, Cary, NC, USA). Pearson correlation coefficients were evaluated to describe the relationship between variables using partial correlation coefficients (CORR procedure of SAS).

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RESULTS

Swimming training

The aim of this study was to evaluate the physiological effects of swimming training over two-week duration. The mean speed of the horses during training was 60.0 m/min. This study was conducted to determine effects on physiological variables according to swimming training duration. The training track used had a circumference of 30 m, a depth of 1.8 m and a width of 3 m and was performed for 10 min once a day for 14 days.

Heart rate

After swimming training, HR was highest immediately after exercise but gradually decreased ($p < 0.001$). At 10 minutes after rest, D_7 and D_{14} showed significant decreases in HR compared to D_0 (Figure 4.2A). HR was positively related to lactate ($r = 0.719$; $p < 0.001$), glucose ($r = 0.574$; $p < 0.01$), and PCV ($r = 0.473$; $p < 0.001$).

Glucose

The differences in blood glucose levels among the training periods are shown in Table 4.1 and Figure 4.2B. The D_{14} stage had significantly lower blood glucose levels than D_0 and D_7 ($p < 0.001$). In this study, criteria of comparison employed to measure the change in recovery rate are fixed to 100%, which is the condition right after exercise. Figure 4.2 shows the recovery rate according to the type and time of rest and all figures are converted into a percentage. Blood glucose levels showed a strong relationship with lactate levels ($r = 0.716$; $p < 0.001$).

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Lactate

Blood lactate levels before training at all stages were less than 1 mol/L and all stages experienced the greatest increase in blood lactate immediately after training ($p < 0.001$), and then tended to decrease with the training period. In particular, the D_7 stage had significantly reduced concentrations compared to D_0 (Table 4.1 and Figure 4.2C). Blood lactate levels were positively related to PCV, Hb, and TP.

Packed cell volume

Table 4.2 shows the PCV in relation to training periods at different time points. D_7 and D_{14} had lower PCV values than D_0 after training ($p < 0.001$). Comparing of according to swimming training duration in immediately after training and 10 min rest, in D_7 and D_{14}, all stages showed similar levels (Table 4.2 and Figure 4.2D). PCV showed a positive relationship with TP ($r = 0.521$; $p < 0.001$), and Hb ($r = 0.529$; $p < 0.001$).

Total protein

The levels of blood TP for the training period at the different time points are shown in Table 4.2. and Figure 4.2E. The level of TP did not significantly differ among the training periods. Also, 10 min after rest, all levels recovered to what they were before the start of training; however, recovery rates of TP immediately after training was more efficient at D_7 and D_{14} than at D_0.

Hemoglobin

Hb values at D_7 and D_{14} were significantly decreased compared to D_0, but D_7 values recovered during the rest period (Table 4.2 and Figure 4.2F). Hb levels were positively related to lactate ($r = 0.525$; $p < 0.001$) and PCV ($r = 0.529$; $p < 0.001$).

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Table 4.1. Effect of swim training duration on physiological variables of horses

Variables	Measurement time	Swimming training duration (days)			Significance
		0	7	14	
Heart rate (beats/min)	Before swim	50.80^{a} ±20.76^{A}	49.60^{a} ±10.45	44.00^{a} ±4.24	NS
	After swim	148.8^{a} ±19.0	124.2^{b} ±19.1	132.0^{ab} ±27.6	*
	10 min after rest	93.4^{a} ±30.9	82.8^{ab} ±11.8	70.0^{b} ±10.4	*
Blood glucose concentration (mmol/L)	Before swim	80.60^{a} ±21.00	97.60^{a} ±17.22	86.60^{a} ±11.76	NS
	After swim	118.4^{a} ±18.2	110.0^{a} ±21.5	93.6^{b} ±11.4	*
	10 min after rest	116.6^{a}±18.6	104.6^{a}±17.6	82.4^{b} ±16.0	***
Blood lactate concentration (mmol/L)	Before swim	0.80^{a} ±3.20	0.30^{a} ±2.03	0.22^{a} ±1.02	NS
	After swim	13.03^{a}±3.17	6.40^{b} ±2.91	4.66^{b} ±2.37	***
	10 min after rest	9.96^{a}±4.57	3.28^{b} ±2.37	2.12^{b} ±0.76	***

Levels of significance: NS, not significant; * $p < 0.05$; *** $p < 0.001$.

^{A,b} Means with different superscripts in the same row significantly differ ($p < 0.05$).

^{A} Means ± Standard deviation.

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Table 4. 2. Effect of swim training duration on hematic parameters of horses

Variables	Measurement time	Swimming training duration (days)			Significance
		0	7	14	
Packed cell volume (%)	Before swim	35.80 ^{a} ±7.15 ^{A}	41.20 ^{a} ±15.15	36.80 ^{a} ±5.16	NS
	After swim	59.40 ^{a} ±8.68	45.40 ^{b} ±4.35	42.40 ^{b} ±10.8	***
	10 min after rest	52.00 ^{a} ±8.68	37.80 ^{b} ±9.03	37.60 ^{b} ±10.59	**
Total protein (g/dl)	Before swim	7.04 ^{a} ±0.71	6.88 ^{a} ±1.04	7.12 ^{a} ±0.86	NS
	After swim	8.08 ^{a} ±0.83	7.30 ^{a} ±0.64	7.32 ^{a} ±1.01	NS
	10 min after rest	7.54 ^{a} ±0.86	6.96 ^{a} ±0.73	6.82 ^{a} ±0.84	NS
Hemoglobin (g/dl)	Before swim	18.33 ^{a} ±0.11	11.52 ^{b} ±2.25	13.66 ^{ab} ±4.55	*
	After swim	23.33 ^{a} ±0.72	14.38 ^{b} ±4.77	17.68 ^{b} ±6.16	**
	10 min after rest	22.53 ^{a} ±1.15	11.06 ^{b} ±5.11	14.90 ^{b} ±6.92	***

Levels of significance: NS, not significant; * $p < 0.05$; *** $p < 0.001$.

^{A,b} Means with different superscripts in the same row significantly differ ($p < 0.05$).

^{A} Means ± Standard deviation.

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Table 4.3. Correlation coefficients (*r*) among physiological and hematic parameters of horses

	HR	Glucose	Lactate	PCV	TP
HR					
Glucose	.574**				
Lactate	.719***	.716***			
PCV	.473***	.423**	.639***		
TP	.424**	.126	.393**	.521***	
Hb	.241	.229	.525***	.529***	.137

Levels of significance: ** $p < 0.01$; *** $p < 0.001$.

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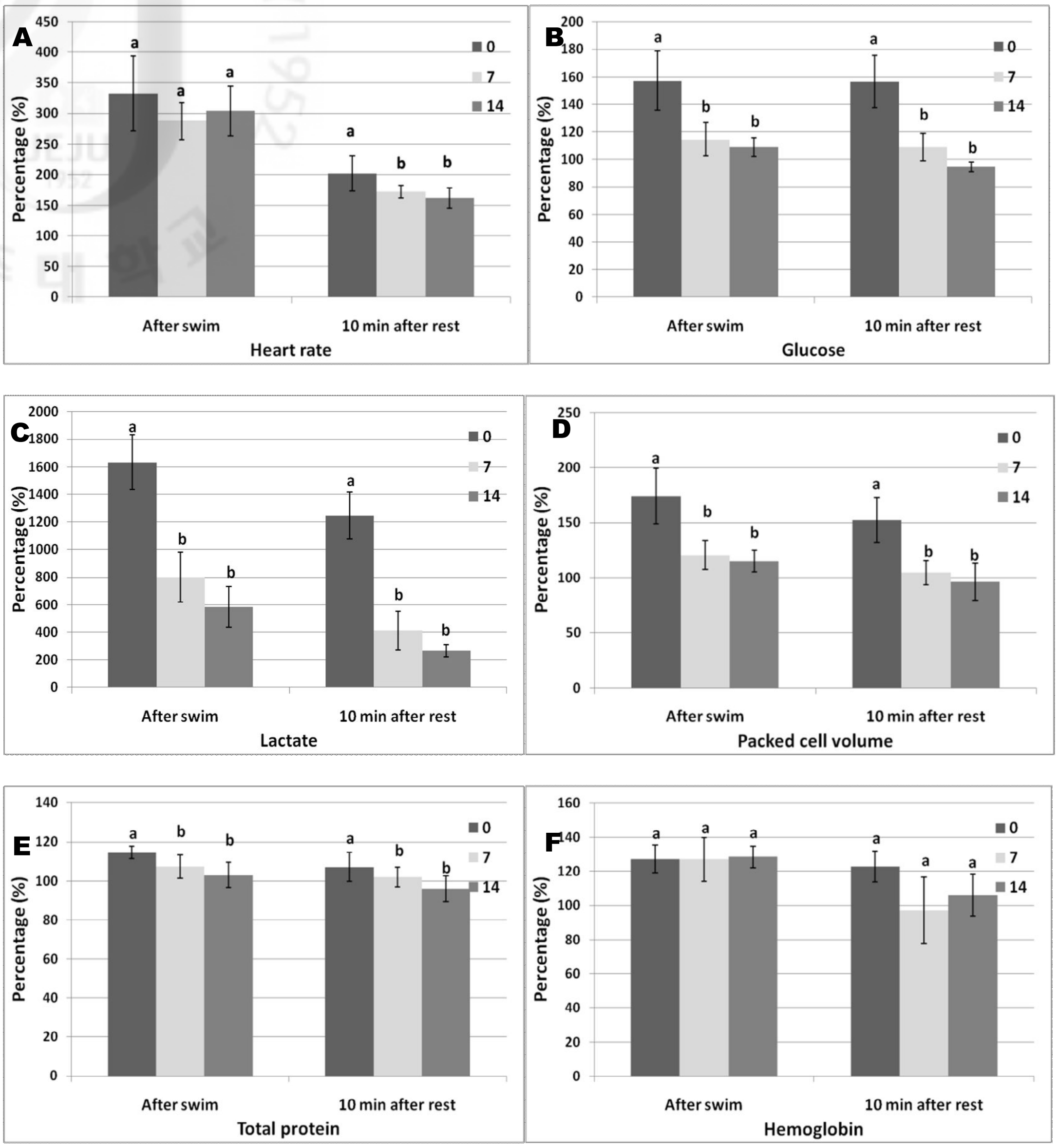

Figure 4.2. Relative changes of physiological and hematic parameters of horses after swim training. A, heart rate; B, glucose concentration; C, lactate concentration; D, packed cell volume; E, total protein; F, hemoglobin. [A,b] Means with different superscripts significantly differ ($p < 0.05$).

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DISCUSSION AND CONCLUSIONS

It is well known that high intensity training results in an increase in the oxidative enzyme activity of muscle (Pluim *et al.*, 2000; Fagard, 2003; Davie *et al.*, 2008). Muscle and blood homeostasis may dramatically change under exercise conditions (Westerblad and Allen, 2003) and continuous efforts cannot be effectively applied unless an adequate restoration of homeostasis occurs (Toubekis *et al.*, 2008).

Certain hematological adaptations are necessary to guarantee an adequate supply of oxygen and blood-borne substrates to active muscles during exercise and for the removal of metabolites (Piccione *et al.*, 2007). The body must be properly prepared if the benefits of exercise are to be garnered safely. This study was performed to identify physiological changes in horses during two weeks of swimming training. Each animal circled the swim track for 20 laps (60.0 m/ min) during the swimming training. The results indicated that changes in physiological traits following swimming training were dependent upon the training period.

Immediately after exercise, there were significant differences in HR during the D_7 training period compared to D_0 ($p < 0.001$). If the rate prior to exercise was considered as 100%, when compared to immediately after exercise and after a 10 minutes rest, the D_{14} stage showed the fastest decrease in HR (~142%). In this experiment, the pre-training HR ranged from 44 to 51 bpm and post-training from 124 to 149 bpm. The HR (170-180 bpm; max 75-80%) of a race horse indicates that anaerobic metabolism occurs greatly during exercise due to the significant increase in lactate concentration to threshold levels following anaerobic exercise (Gondim *et al.*, 2007; Ferraz *et al.*, 2008). It is considered that the training of a riding horse is less restrictive than that of a racehorse in terms of speed during ordinary training procedures.

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Regarding blood glucose concentration after exercise, D_0 and D_7 stages had similar values but D_{14} had significantly different values ($p < 0.001$). The decreasing rates at D_{14}, D_7, and D_0 stages were approximately 14%, 5.58%, and 0.58%, respectively. It is suggested that the glucose level in the D_{14} stage is the result of fast recovery from high-intensity training. Previous studies showed an increase in blood lactate concentration in anaerobic metabolism of horses (Ferraz *et al.*, 2007, 2008; Piccione *et al.*, 2010).

Onset of blood lactate accumulation (4 mmol/L) has been used as a criterion to evaluate the exercise capacity of horses (Gondim *et al.*, 2007; Lindner *et al.*, 2009; Piccione *et al.*, 2010). Thus, lactate production and removal are very important during anaerobic exercise and relevant to the interpretation of blood lactate concentrations (Gondim *et al.*, 2007). The results in this study showed the marked increase of blood lactate level immediately after training ($p < 0.001$). Blood lactate concentration tended to decrease depending on the training period. In particular, it was significantly reduced at D_7 compared to D_0.

When comparing each value immediately after exercise, D_0, D_7, and D_{14} lactate production was 1600%, 800%, 580%, respectively. These results indicated that lactic acid formation diminished as the duration of training increased. In addition, recovery rate at D_{14} was even faster than that at D_0. Both D_7 and D_{14} lactate levels decreased below 4 mmol/L after a 10 min rest, which showed no excess recovery.

The reduction of blood lactate reflects the improved metabolic efficiency of the horses. Kang *et al* (2011) reported the lactate concentration level recovered to the threshold of 4 mmol/L after 15 minutes rest in the high- intensity exercise. Also, Piccione *et al.* (2010) reported on a trot group with a very low lactate accumulation level after exercise. In this study, PCV was used to evaluate dehydration and anemia.

Typically, the optimum level of PCV in horses is close to 40%, and levels below 32% or above 48% indicate problems. Below 30% of PCV is considered anemic, and efforts

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should be made to identify the reason for the lack of red blood cells. This study identified significant changes in PCV immediately after training and after a 10 minutes rest compared to levels prior to training. TP of blood was also measured as an aid in estimating hydration status. There were no significant differences when comparing stages.

Hb levels showed a quick recovery rate compared to levels prior to training. Also, when comparing immediately before and after the training, the recovery rate of Hb immediately following exercise dramatically declined compared to what it was before exercise. Taken together, the changes realized after training demonstrate the effects of swimming on physiological adaptation of the horses.

Jones *et al.* (2002) found peak expiratory pressures in horses to be higher during swimming than galloping and that horse breath five times slower while swimming than galloping. In horses, aerobic training escalates cardiopulmonary function, muscular strength, and blood release rate by strengthening the heart, which causes less fatigue despite rapid running. In addition, anaerobic training gives rise to rapid fatigue recovery by decreasing physical energy output when the horse speeds up enhancing removal of accumulated fatigue materials. Therefore, aerobic and anaerobic methods should be combined in horse training.

This study has great significance in that it is the very first study to consider the effectiveness of swimming training on riding horses. Equine blood lactate concentration is generally below 1 mmol/L. With increased exercise intensity, concentrations below 4 mmol/L indicate aerobic exercise whereas levels above 4 mmol/L indicate anaerobic exercise. According to a study by Knudsen and Jrgensen (2000), swimming was observed to decrease lactic acid formation more than an average quick pace on land, and as such is considered a viable substitute training method to reduce injuries resulting from excessive tension. In addition, swimming is seen as an effective means to train the cardiovascular system as well as both aerobic and anaerobic muscle capacity. Davie *et al.* (2008) also reported that swimming produced less lactic acid formation than track training.

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Knudsen and Jrgensen (2000) suggested that swimming could be substituted for the traditional training of horses in order to improve the cardiovascular system and the aerobic and anaerobic capacities of the musculature. Swimming training is considered an effective method in terms of maintaining or developing equine cardiovascular function.

In conclusion, after 14 days of swimming training, HR ($p < 0.05$), blood glucose ($p < 0.05$), lactate ($p < 0.001$), PCV ($p < 0.01$), and Hb ($p < 0.01$) measured immediately after swimming and after 10 minutes rest showed significant lower values than those of D_0. Horses in this study demonstrated rapid lactate recovery (below 4 mmol/L) during both swim training sessions after a 10 minutes rest (Table 4.1). Lactate concentrations at D_0, D_7, and D_{14} immediately after exercise were 13.03±3.17, 6.40±2.91, and 4.66±2.37 mmol/L (Table 4.1).

Lactic acid formation dramatically diminished compared to levels prior to swimming, indicating a large difference depending on training periods. These results illustrate the benefits of swimming training for riding horses and the need for the establishment of swimming routines of appropriate duration (despite the short period of two weeks) and intensity to maximize the advantages of swimming training.

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CHAPTER 5

EFFECTS OF THERAPEUTIC RIDING FOR CHILDREN WITH SPASTIC CEREBRAL PALSY

ABSTRACT

The aim of the present study was to examine the effect of therapeutic riding in children with spastic cerebral palsy using Jeju crossbred horses. Participants included Therapeutic riding (TR) group (n=7) and physical therapy (PT) group (n=7). Therapeutic riding was conducted for 30 minutes, twice a week for 8 weeks.

The Denver Developmental Screening Test (DDST) and Gross Motor Function Measure (GMFM), Range of Motion (ROM), and Spasticity Test (ST) were used to assess the efficacy of the treatment at pre, mid, and post-test. We used the SPSS 12.0 statistical software for data analysis.

When we detected significant differences, we separated the mean values by the paired sample t-tests at a predetermined probability rate of 5%.

The personal-social of DDST at the TR2 therapeutic riding was higher than at the TR0 therapeutic riding. We observed significant changes in GMFM Dimension C (crawling and kneeling), D (standing), and E (walking, running, and jumping) between TR2 and TR0. Also, the development of gross motor functions was positively correlated to the personal-social (PS), fine motor-adaptive (FMA), and language skills.

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In future studies we will consider using a therapeutic riding program for the treatment of children with disorders.

Keywords: Cerebral Palsy; Equine Assisted Therapy; Rehabilitation; Therapeutic Riding

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INTRODUCTION

The horses can play a very different role in the lives of children and adults with disabilities. Through both hippotherapy and therapeutic riding, organizations all over the country are bringing the experience of horse-related therapies to those in need and changing the lives of individuals with special needed and their families. Especially, children, have gravitated toward them and many experience their first horseback riding lesson at a young age. Therapeutic riding is defined as using horseback riding to improve posture, balance, and mobility, while developing a therapeutic bond between the patient and horse (All *et al.*, 1999). The benefits of therapeutic riding, including improvements in balance, coordination, spasticity, postural control, gross motor function, have been reported in patients with cerebral palsy (McGibbon *et al.*, 2009; Shurtleff *et al.*, 2009).

Cerebral palsy (CP) is an umbrella term that encompasses a group of non-progressive, non-contagious motor conditions that cause physical disability in human development, chiefly in the various areas of body movement (Nelson and Russman, 2002). It is a chronic condition that often requires lifelong participation in physical and occupational therapy (Ionatamishvili, 2004). CP can also lead to other health issues, including vision, hearing, and speech problems, and learning disabilities.

The three types of CP are spastic cerebral palsy, athletic cerebral palsy, ataxic cerebral palsy. Spastic cerebral palsy refers to a condition in which the muscle tone is increased, causing a rigid posture in one or more extremities [arm(s) or leg(s)]. Often the spasticity occurs on one side of the body (hemiparesis), but it can also affect the four limbs (quadriparesis) or be limited to both legs (spastic diplegia).

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Spasticity can be inhibited through the saddle position in hip flexion-abduction-external rotation as well as through rhythmical and three dimension equine movement communicated to the patients' pelvis and trunk (Lechner *et al.*, 2003). Of central importance is that the three dimension rhythmic movement of the horse stimulates a human walk; a horse's stride moves the rider's pelvis with the same rotation side to side movement that occurs while walking (Lessick, 2004).

The qualitative results of a previous study demonstrated weekly progress in the sitting posture and attention span of children (Young, 2005). According to Lessick, among the psychosocial benefits reported with riding are improvements in self-esteem, self-image, and interpersonal skills (Lessick, 2004). Kwon *et al.* (2011) reported functional improvement in Dimension E (walking, running, and jumping) of the GMFM, and balance after hippotherapy for 30 minutes twice a week for 16 sessions.

Sterba *et al.* (2002) reported that hippotherapy significantly increased gross motor functioning in fourteen children with CP with varying levels of gross motor functioning. Spastic CP is the most common form of cerebral palsy, affecting 70 to 80 percent of patients. Spastic CP refers to an increased tone, or tension, in muscle.

Muscles affected by spastic cerebral palsy become active together and block effective movement. Spastic cerebral palsy also limits stretching of muscles in daily activities and results in the development of muscle and joint deformities. Thus, there is a need to evaluate the effects of horse riding on spastic cerebral palsy. However, there have been very few studies that measured the effects of therapeutic riding programs, on improving gross motor function in children with CP.

The aim of the present study was to examine the effect of therapeutic riding on DDST, GMFM, ROM and ST in children with spastic cerebral palsy using Jeju crossbred horses.

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MATERIALS AND METHODS

Participants

Fourteen children diagnosed with CP participated in the study at the Jeju Horse Land in Jeju city, Jeju island (Table 5.1). All participants were recruited from the Ever Spring Rehabilitation Hospital in Jeju city, Jeju island, South Korea.

Participants received the riding program at no cost after they agreed to participate and their parents signed the consent forms. Participants included Therapeutic riding (TR) group (physical therapy -plus- horse riding, n=7) and physical therapy (PT) group (physical therapy, n=7) (Table 5.1). The TR and PT groups consisted of four children with diplegia and three children with hemiplega, respectively.

Horses

The horses used were three clinically healthy Jeju crossbred horses, three females, 14.5 ± 0.7 yr of age, weight 322.5 ± 3.5kg, withers heights 128.0 ± 1.7 cm and chest width 67.5 ± 0.7cm. According to the official manual for RDA, a good behavior, calm and good temperament is essential for equine assisted therapy. If the horse’s temperament is suitable, the horse's body type becomes an important selection criterion (RDA, 1990).

Horses used for therapeutic riding must be short and wide (Matsuura *et al.*, 2008). Therefore, the horses used in this study had a shorter and wider body type.

Experiment design

An experiment design model was used to determine the effects of Therapeutic riding program (Figure 5.1). The participants were divided into two groups: therapeutic riding (TR) group and physical therapy (PT) group.

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Therapeutic riding program was provided by registered instructor in PATH *Intl.*. Also, horses and participants were appropriately matched depending on the size by the same instructor. TR group sessions were conducted by a certified instructor in PATH *Intl.* .

The PT group received physical therapy by physical therapists for 16 sessions in the hospital. In order to analyze the participants' abilities, the activities of daily living and GMFM were analyzed before therapeutic riding (TR0), after 8 sessions of therapeutic riding (TR1), and after 16 sessions of therapeutic riding (TR2). All participants were asked to wear helmets for safety. Volunteers were used, where one was the leader and two were side walkers.

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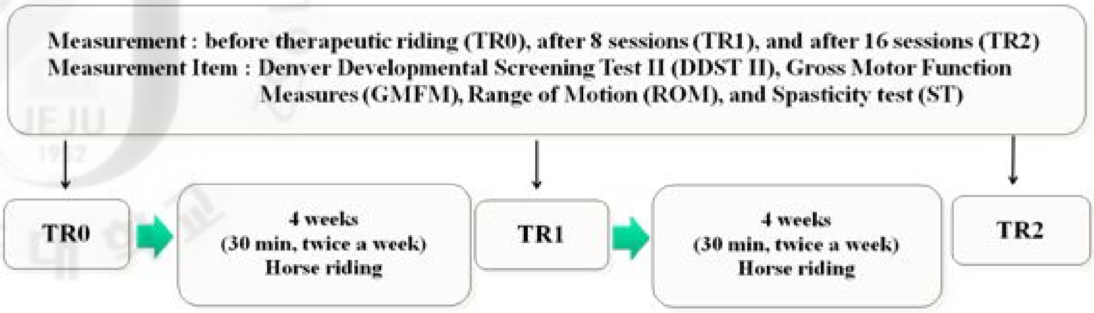

Figure 5.1. Experimental Design

Figure 5.2. Photo of experimental in children with CP

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Measurements

Therapeutic riding was conducted for 30 minutes, twice a week for 8 weeks. Each measurement was performed three times at pre, mid, and post-test. All measurements of the participants were conducted by the same occupational therapist and physical therapists at the Ever Spring Rehabilitation Hospital. The DDST and GMFM, ROM, and ST were used to assess treatment at pre, mid, and post-test.

Denver Developmental Screening Test II (DDST* II*)

The DDST, commonly known as the Denver Scale, is a test used to assess the developmental progress in preschool children. It was originally designed at the University, Colorado Medical Center, Denver, USA. The test consists of up to 125 items, divided into four parts: PS, FMA, language, and GM functions.

In 2006, the American academy of pediatrics council on children with disabilities; section on developmental Behavioral Pediatrics published a list of screening tests for clinicians to consider when selecting a test to use in their practice. This list includes the DENVER II among its choices in American Academy of Pediatrics (AAP, 2006). DDST was used to determine the developmental age.

Gross Motor Function Measures (GMFM)

The GMFM has been demonstrated to have high levels of validity, reliability, and responsiveness in assessing motor function and the effects of physical therapy in children with CP (Russell *et al.*, 1989; Bjornson *et al.*, 1998). Therefore, the GMFM was chosen as a tool to measure clinical changes in participants associated with horseback riding (Sterba *et al.*, 2002).

The GMFM consists of 88 items organized into five dimensions: (A) Lying and Rolling; (B) Sitting; (C) Crawling and Kneeling; (D) Standing; and (E) Walking, Running,

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and Jumping. The Total GMFM score was derived by averaging the percent scores for all five Dimensions (A through E), in accordance with the GMFM training manual (Russell *et al.*, 1993).

Range of Motion (ROM) and Spasticity test (ST)

ROM is one of the many physical benefits of therapeutic riding. It can be further increased through activities such as mounting, dismounting, saddling, unsaddling and grooming (Bliss, 1997). It is a measure of musculoskeletal flexibility or the amount of movement a person can achieve at each joint (Benda *et al.*, 2003). In this study, the range of motion in joints and spasticity test were used to assess the rider at pre, mid and post-test.

Statistical analysis

SPSS 12.0 statistical software was for data analysis. When significant differences were detected, the mean values were separated by the paired sample t-tests at a predetermined probability rate of 5%. The results were presented as means of the groups together with standard deviations. Pearson correlation coefficients were evaluated to describe the relationship between variables using partial correlation coefficients of SPSS.

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RESULTS

Denver Developmental Screening Test II (DDST* II*)

Table 5.2. Shows the monthly average value of each item measured in the DDST before and after therapeutic riding. The personal-social (M=36.0) of DDST at TR2 therapeutic riding was higher than TR0 therapeutic riding (M=34.3).

Fine motor-adaptive and language of DDST were higher at TR2 (M=42.3, 47.3) than TR0 (M=39.3, 46.4). However, there were no significant differences. Significant differences in GM were between TR2 (M=33.0) and TR0 (M=25.0) in DDST ($p < 0.05$). No significant differences between PT0 and PT2 were observed relative to the control group (Table 5.2 and Figure 5.3).

In the correlation analysis among the measured items at DDST (Table 5.4), the personal-social factor was positively related to the fine motor-adaptive development months (r=0.965). A similar tendency was also observed between the language and fine motor-adaptive (r=0.864), the gross motor and personal-social(r=0.873), the gross motor and fine motor-adaptive (r=0.898) and the gross motor and language (r=0.833).

Gross Motor Function Measures (GMFM)

Means and standard deviations on all subscales for the pre-test and post-test for TR and physical therapy groups are reported in Table 5.3. The experimental group was significant different in the GMFM Dimension C (crawling and kneeling), D (standing), and E (walking, running, and jumping) between TR2 and TR0. However, no significant differences were observed in the Dimension A and B during therapeutic riding.

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In the control group, GMFM Dimension B (sitting) and E (walking, running, and jumping) were significantly different during physical therapy ($p < 0.05$) between PT2 than in PT0.

In the correlation analysis among the measurement items at GMFM (Table 5.4), the Dimension B and D (r=0.984) and C and E were positively related (P<0.01). In addition, the C and D (r=0.787), Band E (r=0.832), and D and E (r=0.840) were positively correlated.

Range of Motion (ROM) and Spasticity test

There was no difference in the range of motion and spasticity between the experiment and control groups.

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Table 5.1. Physical characteristics of children by age and gender

	Treatment			Control		
Participant	Age	Gender	Type of CP	Age	Gender	Type of CP
1	4	M	Diplegia	5	F	Diplegia
2	6	M	Diplegia	4	M	Diplegia
3	7	M	Diplegia	7	M	Diplegia
4	9	M	Diplegia	12	M	Diplegia
5	5	F	Hemiplegia (Rt.)	5	M	Hemiplegia (Rt.)
6	10	M	Hemiplegia (Lt.)	7	M	Hemiplegia (Lt.)
7	14	M	Hemiplegia (Rt.)	9	M	Hemiplegia (Lt.)

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Table 5.2. Changes in the scores of DDST Ⅱ in the children of treatment and control group

	Pre-test		Post-test		Paired t-test	
	Mean	SD	Mean	SD	T-value	P-value
Treatment group						
Personal-Social	34.3	26.4	36.0	25.5	-1.520	.179
Fine Motor-Adaptive	39.3	24.6	42.3	23.0	-1.515	.181
Language	46.4	26.8	47.3	26.1	-1.549	.172
Gross Motor	25.0	17.8	33.0	22.8	-3.266	.017*
Control group						
Personal-Social	36.5	40.3	37.5	39.5	-1.414	.252
Fine Motor-Adaptive	39.5	39.2	41.2	37.7	-1.698	.188
Language	40.7	39.4	43.0	37.3	-1.567	.215
Gross Motor	18.5	15.8	22.5	19.2	-2.248	.110

Levels of significance: $^*p < 0.05$

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Table 5.3. Changes in the scores of GMFM in the children of treatment and control group

	Pre-test		Post-test		Paired t-test	
	Mean	SD	Mean	SD	T-value	P-value
Treatment group						
A	95.7	7.3	99.7	0.8	-1.528	.177
B	97.9	3.7	99.0	2.6	-.703	.508
C	83.0	13.4	89.9	8.1	-2.529	.045*
D	67.3	31.6	88.3	17.2	-2.559	.043*
E	55.0	34.8	71.6	28.9	-2.771	.032*
Control group						
A	99.7	7.6	100.0	0.0	-1.000	.356
B	98.3	1.3	99.6	1.1	-2.714	.035*
C	85.6	7.0	86.9	8.6	-1.000	.356
D	62.1	24.4	69.7	23.6	-2.340	.058
E	44.4	21.2	64.1	21.0	-2.955	.025*

Levels of significance: $*p < 0.05$

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Table 5.4. Correlation coefficients among DDST Ⅱ and GMFM score rate during therapeutic riding

	DDST				GMFM			
	PS	FMA	Lang.	GM	A	B	C	D
PS								
FMA	.965**							
Lang.	.751	.864*						
GM	.873*	.898**	.833*					
A	.069	-.049	.056	.058				
B	.381	.546	.499	.445	-.167			
C	.833*	.875**	.723	.848*	.101	.751		
D	.400	.578	.445	.477	-.264	.984**	.787*	
E	.657	.797*	.771*	.809*	-.205	.832*	.899**	.840*

PS = Personal-Social; FMA = Fine Motor-Adaptive; Lang = Language; GM = Gross Motor

Levels of significance: *p < 0.05; **p < 0.01.

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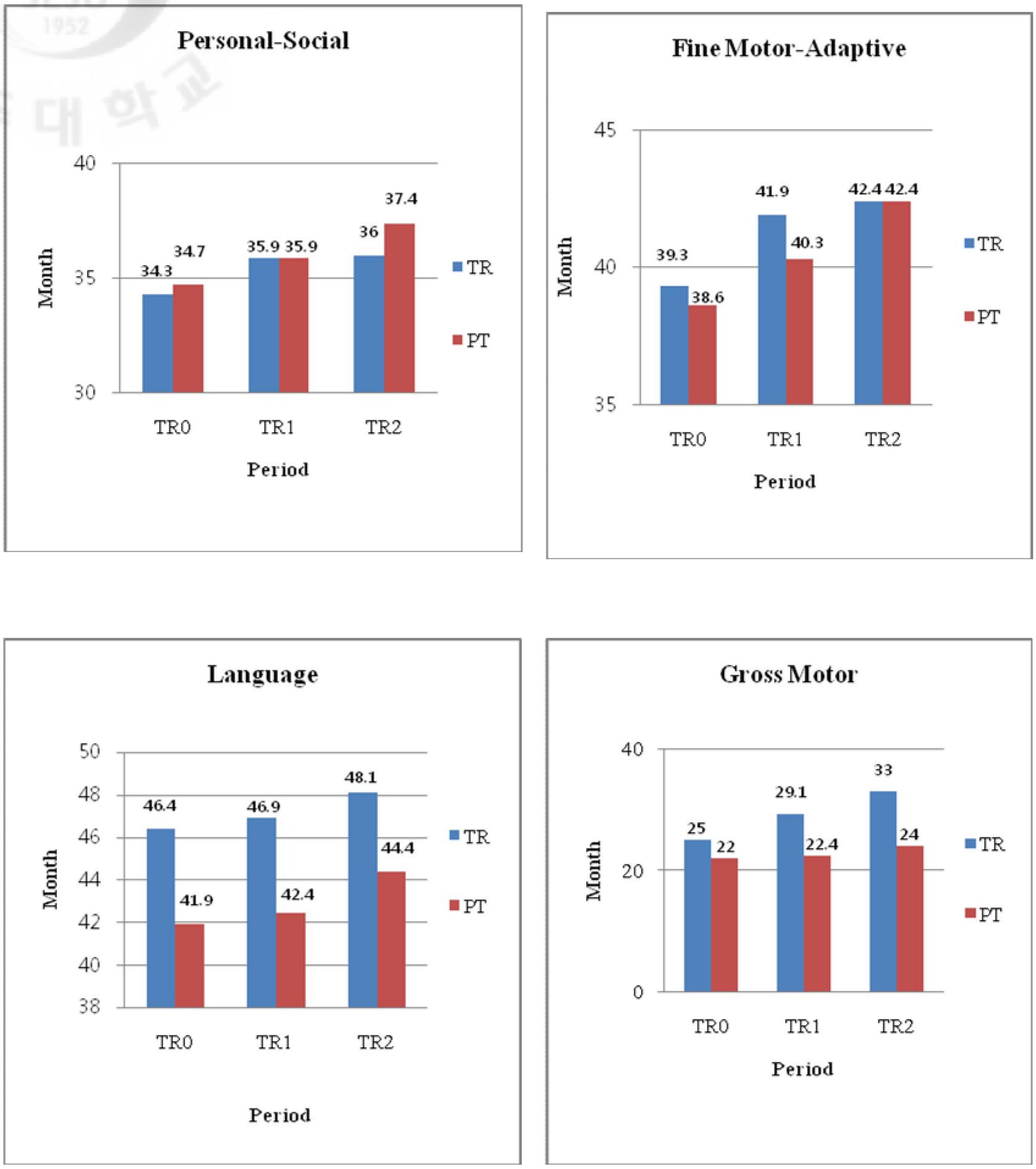

Figure 5.3. Changes in the scores of DDST Ⅱ in the children of treatment and control group

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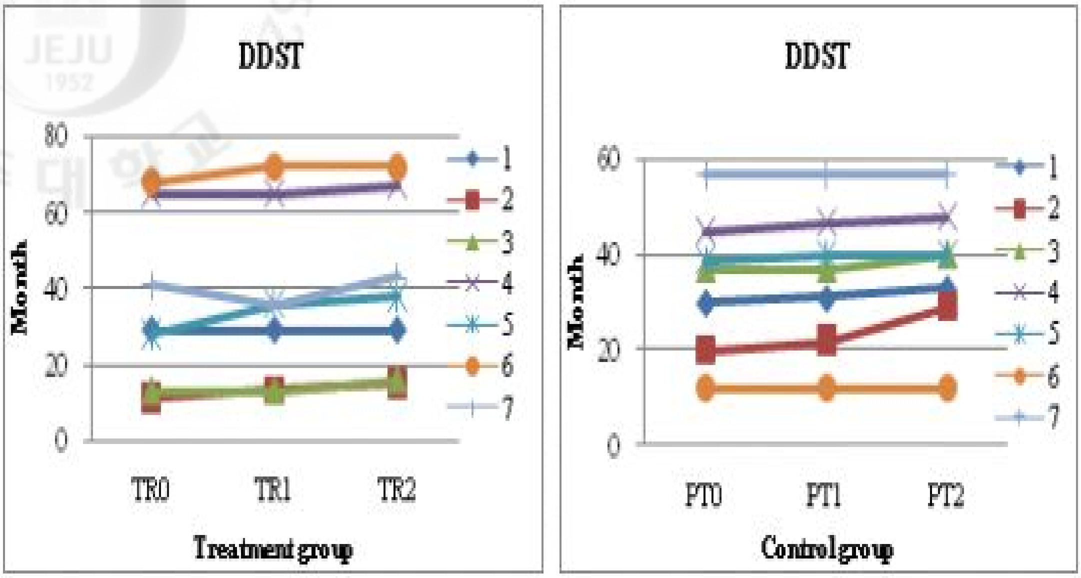

Figure 5.4. Changes in the individual DDST Ⅱ score

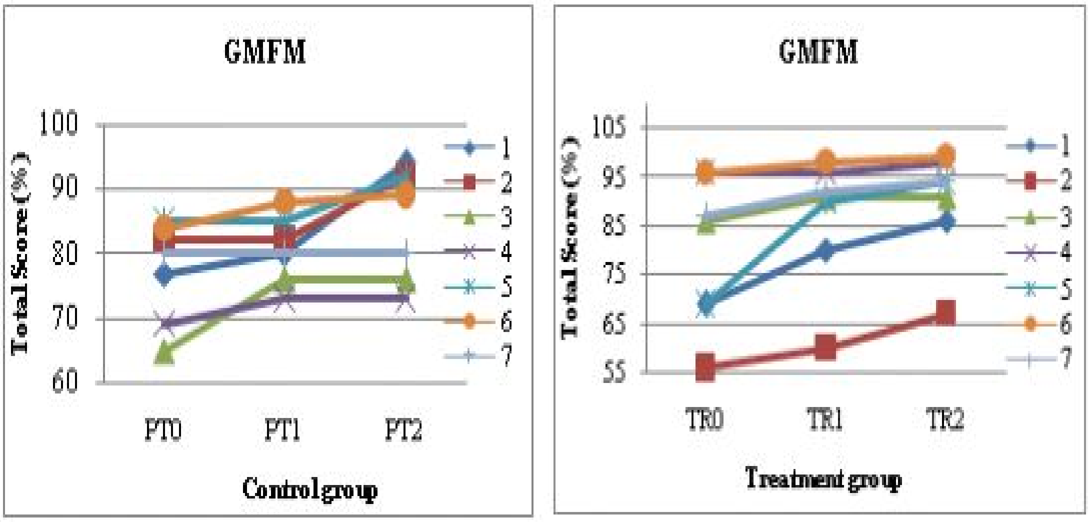

Figure 5.5. Changes in total GMFM score (%) of treatment and control group

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DISCUSSION AND CONCLUSIONS

Therapeutic riding, a subtype of animal assisted activities, has often been used to treat patients with physical and mental disabilities (Sterba *et al.*, 2002). The purpose of horseback riding therapy is to improve the rider's ability to process body-wide sensory information from the rhythmical movements made by the horse (Spink, 1993).

The warmth of the horse and its movements have been hypothesized to improve circulation, reduce abnormally high muscle tone, and promote relaxation in children with spastic CP (Depauw, 1986; Bertoti, 1988). In the DDST of this study, the experimental group showed significant differences in gross motor control ($p < 0.05$). However, we observed no significant differences with the control group (Table 5.2). Shih *et al.* (2008) showed that the cerebellum plays a critical role in sensory acquisition and discrimination (Shih *et al.*, 2008). The cerebellum is primarily involved in motor control and locomotion. The cerebellum also has reciprocal pathways with the visual, auditory, and somatosensory cortices (Zhua *et al.*, 2006). More recently, the cerebellum was implicated in social, cognitive, and emotional functions (Bauman and Kemper, 2005). It is possible that therapeutic riding, fully engages all of the cerebellar functions, since it requires social engagement, motor control, and motor learning skills (Bass *et al.*, 2009).

Horseback riding can improve balance, coordination, spasticity, postural control, and gross motor function, as previously reported in patients with cerebral palsy (McGibbon *et al.*, 2009; Shurtleff *et al.*, 2009). Horstmann and Bleck (2007) reported that of all the motor problems in cerebral palsy, deficient equilibrium reactions interfered the most with functional walking.

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Balance and equilibrium are abnormal in cerebral palsy, particularly in the anterior-posterior plane (sagittal plane) (Gage, 2004). Because two-thirds of the mass of the head, arms, and trunk are located at about two-thirds of the body's height above the ground, the body is essentially an unstable pendulum. The hip is the center for balance control because the forces and/or postural compensations necessary to maintain the head, arms, and trunk segment balanced over the lower limbs are much smaller when applied at the hip than when applied more distally at the limbs (Gage, 2004). In this study, changes in the GMFM dimension C (crawling and kneeling), D (standing), and E (walking, running, and jumping), D, and E were observed with therapeutic riding ($p < 0.01$).

In a previous study, Davis et al reported that participation in a 10-week program did not result in increased gross motor function. However, this study program was performed on a group basis and the riding period was short (30min a week for 10 sessions). Kwon *et al.* (2011) reported significantly improved scores for the dimension E of the GMFM and pediatric balance scale (PBS). Silkwood-Sherer (2007) demonstrated a statistically significant improvement in balance as measured using the Berg Balance Scale and POMA 7 weeks after hippotherapy intervention.

During therapeutic riding, riders learn to make postural adjustments due to the moving horse and to maintain their position. Therapeutic riding uses locomotor impulses emitted from the back of the horse while the horse is walking (Janura *et al.*, 2009). Previous studies reported that therapeutic riding had a positive effect on gross motor function (Sterba *et al.*, 2002; Kwon *et al.*, 2011). In this study, improved gross motor function was found to be highly related to the gross motor and personal-social functions (r=0.873), the gross motor and FMA functions (r=0.898), and the gross motor and language functions (r=0.833) during the period of therapeutic riding (Table 5.4).

Sterba *et al.* (2002) reported that horseback riding as therapy was associated with improvements in total gross motor functions.

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Horseback riding was associated with improvements in gross motor function in 17 children with CP, not only in the GMFM total score but also with improvements in GMFM Dimension E (Walking, Running, and Jumping), which persisted 6 weeks after the completion of horseback riding therapy (Sterba *et al.*, 2002).

In our study, the post intervention GMFM C, D, and E scores were significantly different in the post-test. These studies are quite compelling, even though there has been little work conducted on spastic cerebral palsy. Our findings are compatible with the view that therapeutic riding can have a positive effect on cerebral palsy (Figure 4.5 and 5.5). However, no differences were observed in the ROM and spasticity test between the pre-test and post-test. According to Bergene (2006), increases in hip ROM over all angles measured were observed over the first 12 weeks. This study was conducted for 45min, for 18 weeks.

Therapeutic Riding (TR) is a riding program where the primary objective is therapy rather than recreation or learning the skill of riding (Cherng, 2004). One type of TR is rehabilitative riding, which is a type of treatment that uses movements of the rider to maintain control of the horse (Mackinnon, 1995). Our study focused on testing the effectiveness of therapeutic riding on the rider's physical strength and physical formation with the saddle and stirrups on the horse. In addition, our study was shorter and lasted for less time per session than Bergene's study (Bergene, 2006).

Many researchers have reported an increase in the score Dimension E (Walking, Running, and Jumping) (McGibbon *et al.*, 1998; Kwon *et al.*, 2011), but no significant differences in Dimension D (Standing) were observed. Significant differences in Dimension C, D, and E of GMFM were found in this study.

This result was believed to be due to the effect of standing in the stirrups during therapeutic riding.

Generally, in horse riding exercise, stirrups exist to sustain the weight of the legs, not the body weight (Kang et al, 2010). However, in this study, instructor dictated the treatment

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group to sustain body weights to straighten their back. As a result, it turned out that the riders on the gross motor function have more efficiency. In other words, although the riders in typical horse riding have difficulty learning of the correct skills, they give positive influence on the gross motor function in children with CP, which was believed to be meaningful.

In conclusion, the results of this study demonstrated significant improvements in the gross motor in DDST and Dimensions C, D, and E of GMFM for the experimental group. These results confirmed that therapeutic riding had a positive effect on the gross motor functions in children with CP. Also, the development of gross motor function was positively correlated to the personal-social (PS), fine motor-adaptive (FMA), and language skills. Thus, the gross motor function was effectively enhanced in children with cerebral palsy. However, horseback riding over sixteen sessions had no impact on the range of motion (ROM) and spasticity test.

Specifically, if no saddle was used in children with spasticity CP, then they were not in contact with the horse, resulting in increased stimulation and the need to work harder to maintain balance and equilibrium. Future studies should consider using a therapeutic riding program for the treatment of children with disorders.

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CHAPTER 6

EFFECTS OF THERAPEUTIC RIDING ON CHILDREN WITH INTELLECTUAL DISABILITIES

ABSTRACT

The purpose of this study was to evaluate the effect of therapeutic riding on the physical fitness in children with intellectual disabilities. Six children diagnosed with intellectual disabilities participated as candidates in this study (Table 6.1). There were three males and three females from a special class in a primary school. Therapeutic riding program sessions were provided twice a week for 8 weeks. All sessions were conducted by an instructor registered with the Professional Association of Therapeutic Horsemanship International (PATH *Intl.*).

Each rider was assessed on balance, coordination, agility, and flexibility before therapeutic riding (T0), after 8 sessions (T1), and after 16 sessions (T2). A comparison of each rider's physical fitness before and after therapeutic riding showed significant differences in balance, coordination, and flexibility. The balance measurement showed that balance lasted longer after therapeutic riding than before. The comparison of coordination and power measurements showed significant differences after therapeutic riding than before

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(p < 0.001). The results of a comparison of agility measurements showed differences after therapeutic riding, but not significant differences.

The results of flexibility measurement in this study increased by a mean of 6.83 cm after therapeutic riding (p < 0.5). The results tended to be greater in the female group than the male group but not significantly so. The average flexibility increased more in the male group than the female group. The results of this study found that therapeutic riding positively increases the physical fitness in children with ID. This data will be useful to understand the importance of a therapeutic riding program and improve the qualitative effects of therapeutic riding.

Keywords: Riding, Horse, Therapeutic riding, Mental retardation, Intellectual disability

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INTRODUCTION

Using animals in a goal-oriented setting for treatment is termed animal-assisted therapy. It can significantly benefit cognitive, psychological, and social domains (Fine, 2006). By learning basic horsemanship from PATH *Intl.* Certified instructors, disabled riders can stimulate their physical, mental, and emotional growth. This activity, called Therapeutic Riding (TR), is designed to increase self-esteem and personal confidence, and facilitate communication and interpersonal effectiveness (Kersten and Thomas, 2000).

A horse's gait is a three-dimensional rhythm, quite similar to a person's gait in that respect (Riede, 1988; Engel, 1997). Therefore, riding a horse is effectively the same exercise with the same results as walking. Muscle coordination, balance, motor development, and tone are all improved in patients riding horses because of the horse's rhythmic movements (Sterba *et al.*, 2002). That movement also improves the posture, strength, and overall body awareness of the rider as well (AHA, 2005).

Children with developmental handicaps, learning disabilities, and intellectual problems can also greatly benefit from TR. Intellectual Disability (ID), defined as an Intelligence Quotient (IQ) under 70, is a general disorder that is often expressed as significantly impaired cognitive functions and deficits in two or more adaptive behaviors. It typically appears before adulthood. http://en.wikipedia.org/wiki/Adaptive_behaviorhttp://en.wikipedia.org/wiki/Intelligence_Quotient Children with ID often have intellectual defects and poor physical activity exercise

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features as well when compared to average children (Greenspan, 1992). In particular, ID children's athletic abilities are deficient in body balance, which causes difficulties in exercise and equilibrium.

Horse riding is an exercise of the whole body that helps physical development by improving balance and flexibility. The characteristics of horse riding are more complicated since it involves a horse and a rider (Belton, 2000). The correct seat position can be achieved so that the shoulder, back, and waist can be relaxed without stiffening. In that posture a rider could readily feel and accept the rhythms of the horse's gait (Belton, 2000; Kang *et al.*, 2010). In this process, we concluded that TR offered basic exercise such as balance, flexibility, agility, and coordination with the right seat position. However, in most previous studies, the papers consisted of children with cerebral palsy, autism, and other disorders (Sterba *et al.*, 2002; Bass *et al.*, 2009; Jane, 2008; Kwon *et al.*, 2011).

Short and wide horse is suitable for TR (Matsuura *et al.*, 2008). Wide horses could be used for relieving muscular tension and for rider who cannot maintain good balance on the horse. The Jeju crossbred horse is short (around 130 cm height) with a round belly. Its short height and wide body gives rider stability. Therefore, the purpose of this study was to evaluate the effect of TR on the physical fitness of riders using the one-legged standing test with eyes closed, the standing long-jump test, the shuttle-run test, and the trunk flexion test in children with intellectual disability (ID) after TR with Jeju crossbred horses.

Defined Terms

Balance: A skill-related component of physical fitness that relates to the maintenance of equilibrium while stationary

Coordination: A skill-related component of physical fitness that relates to the ability to use the senses, such as sight and hearing, together with body parts, in performing motor

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tasks smoothly and accurately

Agility: A skill-related component of physical fitness that relates to the ability to rapidly change the position of the entire body in space with speed and accuracy

Flexibility: A health-related component of physical fitness that relates to the range of motion available at a joint

MATERIALS AND METHODS

Subjects

Six children diagnosed with ID participated in this study (Table 6.1). The subjects were three males (age 10.3 ± 2.5 yr, height 134.0 ± 14.9 cm, weight 40.7 ± 14.0 kg) and three females (age 13.0 yr, height 134.7 ± 1.5 cm, weight 37.0 ± 3.6 kg), from a special class in primary school (Table 6.1). All parents signed consent forms.

Horses

The horses used for therapeutic riding were short and broad (NARHA, 2005). The horses used for this study were three clinically healthy Jeju crossbred horses, both female, 14.4 ± 1.4 yr of age, weight 318.5 ± 2.1 kg, withers height 127.5 ± 0.7 cm and chest width 65.0 ± 2.8 cm. Horses were well-matched to the TR program's needs.

Therapeutic riding program

TR program sessions were provided in a 20 m^2 indoor arena for 30 minutes, twice a week, for 8 weeks at Jeju Horse Land, Jeju island, Korea. All sessions were conducted by a PATH *Intl.* registered instructor (Figure 6.1 and 6.2). At the beginning of the study, the certified TR instructor who led each class selected a trained horse and appropriate tack for

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each child and oriented sidewalkers for specific handling and positioning techniques.

During the treatment session, an experienced horse handler led the horse, and a sidewalker provided assistance in stabilizing and positioning the rider as needed. The instructor seated the riders on their horses and told them to touch different parts of the horse's body. Each rider wore a fitted helmet that was approved for horseback riding by the North American riding for the Handicapped Association (NARHA, 2005).

All sessions had 5 minutes of warm-up, 20 minutes of main exercise, and 5 minutes of cooldown. According to Winchester *et al.* (2002), the TR program went in this manner, "Each treatment session stressed: muscle relaxation and stretching; optimal symmetrical postural alignment; independent sitting and standing balance as able; active exercises for stretching, strengthening and reaching; dynamic weight shifts for facilitating automatic righting and equilibrium reactions; and following commands given by the instructor."

We performed the therapeutic riding treatment protocol described in the study. In part, the protocol was modified for each individual subject's ability to be effectively facilitated by a certified therapeutic riding instructor.

Measurements

Each rider was assessed on balance, general coordination, agility, and flexibility before TR (T0), after 8 sessions (T1), and after 16 sessions (T2) (Figure 6.1). All measurements were done twice after the trial for good recordkeeping. For accurate measurements, all measurements were performed and recorded by the same person. The physical fitness was divided into four kinds as follows:

1) One-legged standing test with eyes closed - Balance

The one-legged standing test with eyes closed was conducted in order to assess the rider's ability to maintain balance. Riders stood up, closed their eyes, opened their arms, and

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bent one knee 90 degrees. The amount of time they could maintain that posture was measured.

2) Standing long jump

A standing long jump was conducted to identify power or coordination in riders. Standing long jump measurements were performed in place without running.

3) Shuttle-run

A shuttle-run was conducted to identify each rider's agility. Three bottles were placed a distance of 5 m apart, and the time it took to move them to the opposite side was measured.

4) Trunk flexion

Trunk flexion was conducted to identify rider flexibility. A rider stood on a table about 40 cm in height. They put their hands up and placed them in the middle of the head and slowly bent the upper body forward without rhythm.

When they bent their upper body as far as possible, the maximum distance that the fingers went down was measured, keeping both hands horizontal with the upper body and both arms fixed for three seconds.

Statistical analysis

Data was analyzed using one-way analysis of variance (ANOVA) for repeated measures with points before TR (T0), after 4 weeks TR (T1), and after 8 weeks (T2).

All data is reported as means ± SD with a significance level of $p < 0.05$ using SAS program (SAS Institute Inc. *ver* 9.1, Cary, NC, USA). The significant differences in TR before and after were separated by the paired *t*-test at a predetermined probability rate of 0.05.

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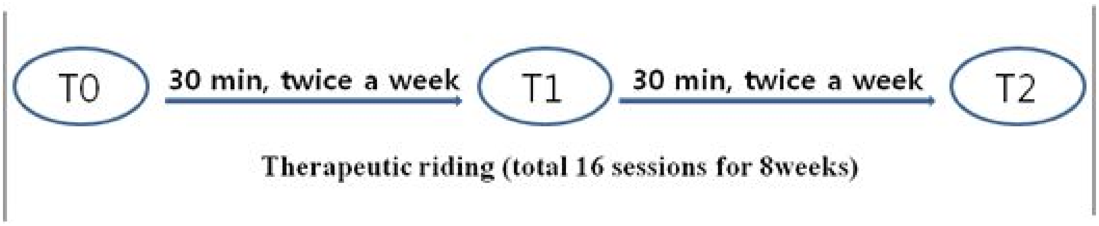

Figure 6.1. Diagram of experimental design

Figure 6.2. Photo of experimental in children with Intellectual Disability

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RESULTS

Changes of rider's physical fitness as period during TR

Table 6.2 and Figure 6.3 Showed the average of each physical fitness test in riders with CP during TR. The comparison of each rider's physical fitness test before and after TR showed significant differences in balance, coordination, and flexibility. The balance test showed that riders lasted longer after (M=4.30 sec) TR compared to before (M=1.72 sec) ($p < 0.05$).

The results of the standing long jump showed significant differences after (M=51.66 cm) TR compared to before (M=84.33 cm) ($p < 0.001$). The results of the shuttle-run showed differences after (M=19.06 sec) TR compared to before (M=23.21 sec), but the differences were not significant. The results of the flexibility test significantly increased after (M= -1.33 cm) TR compared to before (M= -8.16 cm). ($p < 0.5$).

Comparison of gender

Figure 6.3 Showed the average of male and female physical fitness tests for riders with CP during TR. The balance test showed greater increases in the female group than the male group. The male group increased their mean by 1.98 sec after (M=3.80 sec) TR compared to before (M=1.83 sec), and the female group increased the mean by 3.20 sec after (M=4.80

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sec) TR compared to before (M=1.60 sec). In comparison, the balance of males and females were significantly different after four weeks of TR.

In the standing long jump, the male and female groups increased their means by 24.3 cm and 41cm, respectively. The shuttle run was also done faster by the female group than the male group after TR. However, the measurement of trunk flexion was improved greater in the male group than the female group. In comparing the results by gender, the female group tended to show more improvement than the male group, but there was no significant difference. The measurement of flexibility increased in the male group more than the female group (Figure 6.3).

Changes of each rider's physical fitness test scores

All the measurement results of each rider's physical fitness test scores in TR before and after is shown in Figure 6.4. The physical fitness test assessment of before and after TR was observed that improved T2 than T0 (Figure 6.4).

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Table 6.1. Characteristics of Subjects

Subject	Gender	Age	Diagnosis
1	M	8	Intellectual Disability Grade 3
2	M	10	Intellectual Disability Grade 2
3	M	13	Intellectual Disability Grade 2 and Hearing Impairments Grade 4
4	F	13	Intellectual Disability Grade 2 and Cerebral Palsy
5	F	13	Intellectual Disability Grade 2
6	F	13	Intellectual Disability Grade 3

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Table 6.2. Changes of rider's physical fitness before and after therapeutic riding

	BE		AE		Paired t-test	
	Mean	SD	Mean	SD	T-value	P-value
One-legged standing test with eye close -Balance	1.72	0.98	4.30	1.06	-5.602	.003**
Standing long jump - Coordination	51.66	24.98	84.33	24.76	-7.284	.001***
Shuttle-run - Agility	23.21	10.24	19.06	4.95	1.782	.135
Trunk flexion - Flexibility	-8.16	15.01	-1.33	11.58	-3.110	.027*

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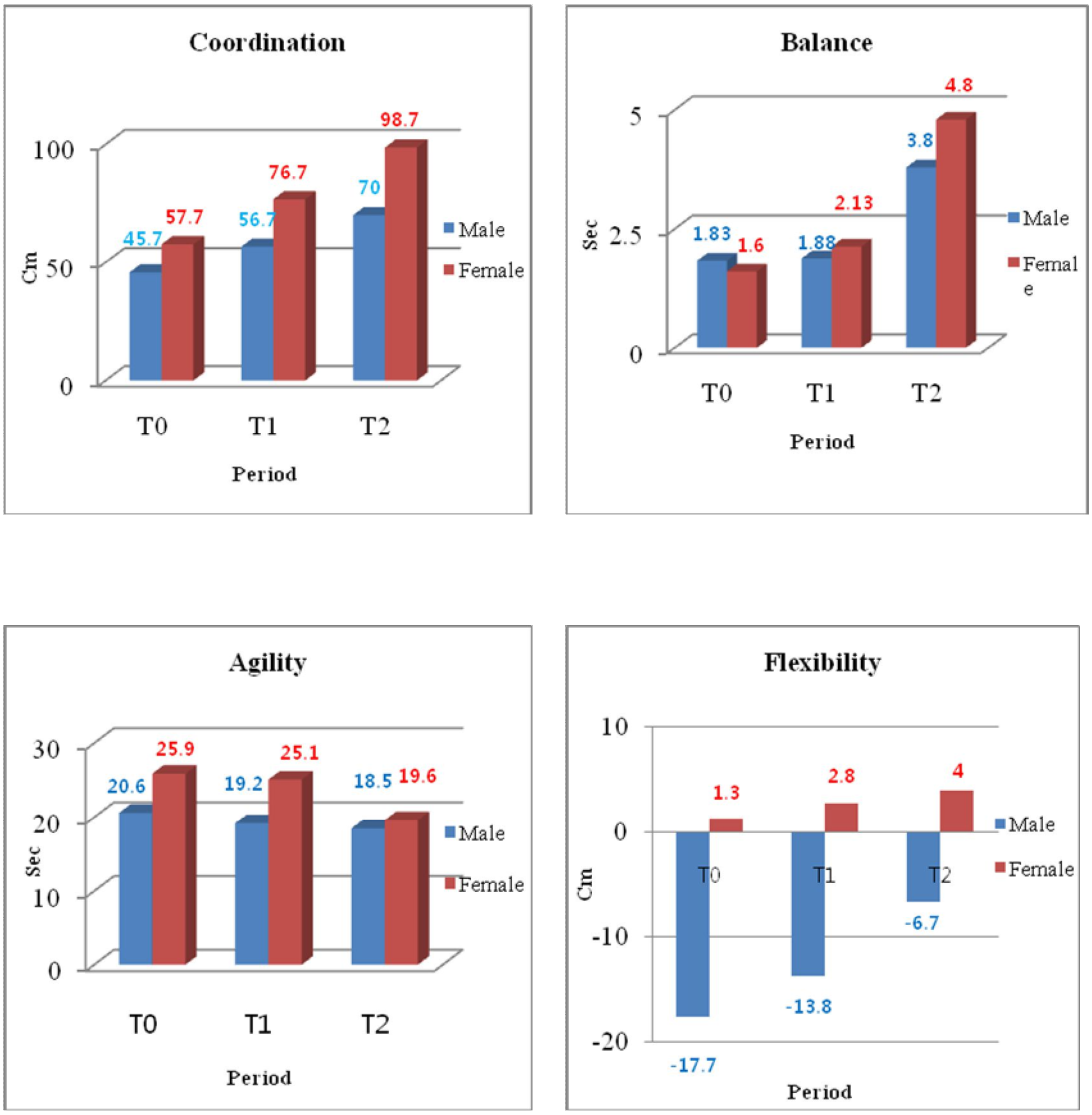

Figure 6.3. Changes of rider's physical fitness test scores according to experimental period in TR

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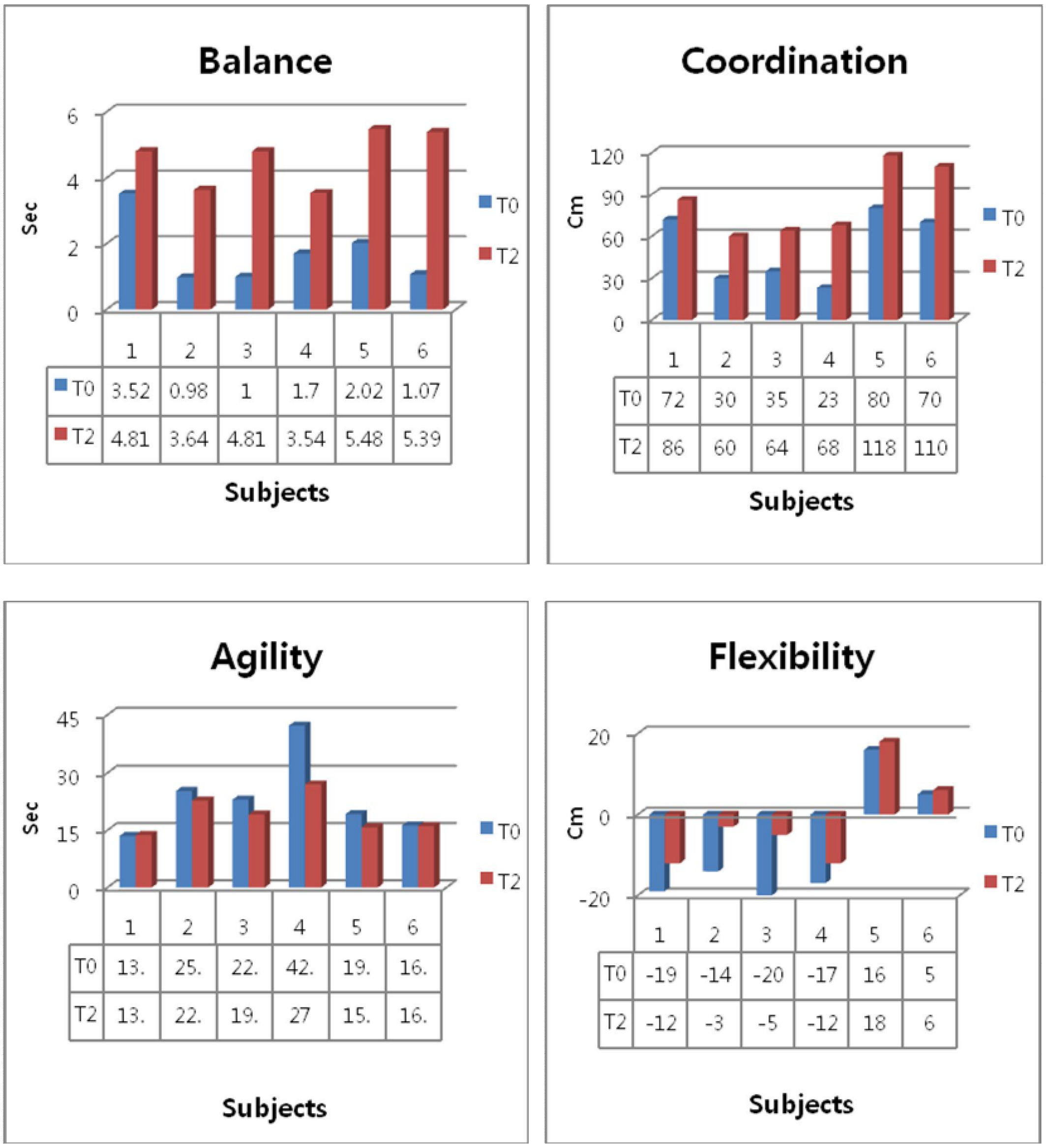

Figure 6.4. Changes of each rider’s physical fitness test scores

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DISCUSSION AND CONCLUSIONS

This study indicated the effects of a TR program on the physical fitness of riders by analyzing a balance test, a standing long-jump test, a shuttle-run test, and a trunk flexion test in children with ID. If a rider was able to carry out the day's activities without undue fatigue, they were classified as being physically fit (Clarke, 1976). Recently, the measure of a body's ability to function efficiently and effectively both during work and play has been defined as physical fitness. People with intellectual disability benefit greatly both from the physical exercise itself and also from meeting the people and seeing the places that they do while performing physical exercise.

Exercise and regimented physical training has been reported to improve the general well-being and self-image of people with ID (Sherrill, 2004; Carmeli *et al.*, 2005). Both adults and the elderly with ID showed great physical improvement after participating in studies of physical activity programs. Any type of physical activity has been shown to cause health benefits, and the health benefits increase if the individual can exercise close to the person's maximum heart rate (Horvat *et al.*, 1993; Rimmer, 2000; Podgorski *et al.*, 2004).

More specifically to therapeutic riding, in patients with cerebral palsy, studies have reported improvements to balance, coordination, spasticity, postural control, and gross motor function (McGibbon *et al.*, 2009; Shurtleff *et al.*, 2009). Kwon *et al.* (2011) demonstrated a

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significantly-improved pediatric balance scale. The Silkwood-Sherer (2007) study also showed a statistically-significant balance improvement based on the Berg Balance Scale and Performance-Oriented Mobility Assessment (POMA) after 7 weeks of riding therapy.

We also observed improved balance, coordination, and flexibility after TR. This is consistent with previous studies (Silkwood-Sherer, 2007; McGibbon *et al.*, 2009; Shurtleff *et al.*, 2009; Kwon *et al.*, 2011).

Most of the previous studies were evaluated through scoring an ability from daily life that changed using the Berg Balance Scale (BBS), Gross Motor Function Measure (GMFM), Gross Motor Function Classification System (GMFCS), and Pediatric Balance Scale (PBS). Typically, measuring physical fitness in disabled persons includes balance, coordination, agility, and power. Therefore, this study is focused on assessing a rider's ability to perform direct physical activity. As treatment of this study, the TR program was conducted in the same manner as with average children.

Physical fitness is based upon the muscular system, the skeletal system, the circulatory system, and the respiratory system. Physical fitness directly relates to balance, coordination, flexibility, power, agility, and endurance. Therefore, in order to improve motor function, physical fitness directly related to exercise should be practices, and then they can exert their physical fitness ability the best. Physical fitness improves through short-term or long-term exercise. The items of the physical fitness test can be expressed quantitatively by physical exercise performance ability and can be compared through differences of gender, age, or ability to appear for each type of disability. There are levels of ID: educable (IQ of 50-70), trainable (IQ of 30 - 49), and totally dependent (IQ < 30).

The children who participated in this study were either educable or trainable. The levels of educable or trainable ID have difficulties learning team games, but basketball, soccer, and baseball are popular activities. A physical activity program for children with ID is desirable to provide individual activities rather than team activities, and gross motor

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activities than fine motor activities. We considered that horse riding is effective as both an individual activity and gross motor activity in persons with ID. During this study, we obtained a good response to subjects and their parents. The results of a comparison in the balance test showed that improvements in duration after TR compared to before ($p < 0.05$). Balance is not a goal for health-related fitness, but it is important in many physical activities and it also has health implications (Oja and Tuxworth, 1995).

According to Han *et al.* (2004), in horseback riding exercises, balance improved in children with cerebral palsy. Also, McGibbon *et al.* (2009) and Shurtleff *et al.* (2009) already reported the benefits of TR, including improvements in balance, coordination, spasticity, postural control, and gross motor function in patients with cerebral palsy (Silkwood-Sherer, 2007; Shurtleff et al, 2009). The results of the standing long jump test showed significant differences after TR. Although measurement methods about coordination and power were different, they supported these studies. In addition, power is the most important factor in evaluating the exercise performance ability in all sports (Johnson and Nelson, 1979). The results of the flexibility test in this study also increased after TR.

The level of flexibility is dependent on the functions of muscles, tendons, and ligaments in the joints. It is always necessary to maintain flexibility for one's entire life to aid balance, coordination, and the locomotor system. Everyday living activities are supported by flexibility, which decreases the incidence of accidents. Individuals with disabilities are often inactive. So they lose flexibility which often complicates simple, everyday movements.

Agility, one of the major components in physical fitness, is usually measured via rapidly changing the position of the body or changing direction quickly while running or walking (Cureton, 1943). The balance test showed significant differences between the female group and the male group. Coordination and agility were showed greater improvement in the female group than the male group.

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Unexpectedly, balance improved greater in the male group than the female group, but not significantly. According to Lovett (2004), the factors that could affect a rider's position are not only technical skills, but also the inertia caused by the horse's propulsive forces and the difference resulting from a horse's height. Also, the result is difficult to generalize because of the small sample size. Thus, the differences between the two groups in TR cannot be assumed to be the differences of effect between male and female. This study has limitations. First, a small sample size makes it difficult to generalize the results. Second, the differences in each rider's personal development, cognitive abilities, motor function height, weight, and type of ID maybe have influenced our results.

Despite the limitations, the research about TR for the disabled is considered effective. In the future, TR will continue to be the subject of a variety of studies on types of disability. Jeju crossbred horses used this study are considered very beneficial to both the riders and the sidewalkers in this program. This study found that TR positively increases the physical fitness of children with ID. This data will be useful for understanding the importance of a TR program and improve the qualitative effects of TR.

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요 약

본 연구의 목적은 승마 및 재활승마에 적합한 체형을 가지고 있는 제주산마를 이용하여 운동생리학적 측면과 재활승마 효과 측면으로 분석되었으며, 말의 복지 및 재활승마의 기초자료로 제공하고자 시행되었다.

운동생리학적 측면으로는 고강도 운동 후 회복기간에 따른 말의 생리적 변화(실험 1), 수영훈련 기간에 따른 말의 생리적 변화(실험 2)를 분석하여 말의 건강 및 수영훈련의 영향에 대해 확인하였다. 또한 재활승마 효과 측면으로는 뇌성마비 아동들을 대상으로 승마운동 기간에 따른 재활승마의 효과(실험 3)와 지적 장애 아동들을 대상으로 장애인의 체력요소인 균형성, 민첩성, 협응성(조정력)과 유연성의 변화(실험 4)를 분석하였다. 이 연구에서 얻어진 결과는 다음과 같다.

실험 1 에서 제주산마의 고강도 운동 후 회복기간에 따른 말의 생리적 변화를 확인하기 위하여 승용마로 이용중인 수말 2 마리와 암말 23 마리를 이용하여 3,000m 승마운동(습보, 10.0m/sec)을 실시한 직후에 심박수를

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측정한 후 혈액을 채취하였다. 채취한 혈액은 혈중 혈당과 젖산 농도를 현장에서 측정분석 하였고, 말의 탈수와 빈혈 정도를 평가하기 위한 충전세포용적(PCV), 총단백(TP) 그리고 혈색소(Hb) 농도는 제주대학교 부속동물병원 임상 병리실에서 분석되었다(실험 3). 3,000m 승마운동 후 휴식방법은 줄을 묶어 휴식하는 그룹(PR), 평보 15 분(WR15) 또는 30 분(WR30) 그룹, 속보 15 분(TR15) 또는 30 분(TR30) 그룹으로 구성되었으며, 측정 시간은 승마운동 전, 승마운동 직후, 휴식 15 분, 30 분, 60 분 후에 실시되었다.

연구의 결과, 심박수는 운동 후 15 분 휴식 경과 후에 모든 그룹에서 유의하게 감소하는 것으로 나타났다. 또한 운동 직후의 수준을 최대로 하여 휴식시간 경과에 따른 변화의 비교에서, 심박수의 회복율은 휴식 30 분 경과 후 정적인 휴식(PR)에 비해 동적인 정리운동 휴식 그룹(WR 또는 TR)에서 운동 전 상태로 빠른 회복율을 보였다. 혈당의 분석결과, 운동 직후의 수준을 최대로 하여 휴식시간 경과에 따른 변화의 비교에서 혈당의 회복율은 휴식 15 분 경과 후 WR15 에서, 30 분 경과 후 WR30 그룹이 빠른 것으로 나타나 평보 휴식 그룹이 효과적으로 나타났다. 또한 젖산 측정결과, 운동 직후의 수준을 최대로 하여 휴식시간 경과에 따른 젖산의 회복율은 속보그룹이 15 분 휴식 후 75%의 감소율을 나타내 매우 긍정적인 효과를 나타냈다. 충전세포용적은 그룹간 차이가 거의 없는 것으로 나타났으며, 총단백과 혈색소 농도는 정적인 휴식이 동적 휴식에 비해 빠른 회복을 보였다. 이는 일반적으로 말은 적혈구의 1/3 까지 비장에 저장되어 있다가 운동이 시작되면 빠르게 혈액으로 쏟아져 나와 산소운반을 담당하고 운동이 종료되면 급격히 환원되는 것과 관련 있는 것으로 사료된다.

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본 연구에서 말의 고강도 운동 후 정리운동 방법에 따른 생리학적인 변화는 확연히 차이가 있는 것으로 나타났다. 따라서, 고강도 운동으로 피로가 축적된 말들은 빠른 회복을 위하여 동적인 정리운동(평보 또는 속보)이 필수적이며 특히 짧은 휴식 시간에 회복을 위해서는 속보를 이용하는 것이 좋을 것으로 판단된다.

실험 2 에서 제주산마의 수영훈련 기간에 따른 생리적 변화를 확인하기 위해 3 년 이상 승용마로 이용중인 암말 5 마리를 이용하였으며, 하루에 10 분(60.0m/분) 씩 14 일 동안 수영훈련을 실시하였다(실험 4).

말의 생리적 특성과 혈액의 변화는 수영 전, 수영 직 후, 10 분 휴식 후 측정되었고, 훈련 첫째 날, 7 일째, 14 일째로 훈련 기간에 따라 측정 되었다. 그 결과, 수영 훈련 전(D_0)과 수영 훈련 14 일(D_{14}) 후의 측정 결과는 심박수(p<0.05), 혈당 (p<0.05), 젖산농도(p<0.001), 충전세포용적(p<0.001), 혈색소(p<0.01)로 수영 실시 전(D_0)에 비해 훨씬 낮은 수치를 나타내었다. 또한 훈련 7 일째와 14 일째에서 수영 직 후 젖산생성 수준이 훈련 첫째 날에 비해 현저히 낮게 생성되는 것으로 나타나 훈련기간에 따른 효과를 나타내었다.

충전세포용적과 혈색소 수치는 수영훈련 7 일째부터 모든 실험 그룹에서 정상범위를 유지하여 빈혈이나 탈수문제는 없는 것으로 확인되었으며, 총단백 또한 모든 실험 그룹에서 정상범위를 유지함에 따라, 제주산마의 수영훈련은 짧은 훈련기간임에도 불구하고 수영훈련의 효과를 제시해 주는 결과로 판단된다.

실험 3 에서 뇌성마비 아동들을 대상으로 재활승마를 실시하여 운동기간에 따른 개선효과를 확인하기 위해 경직성 뇌성마비 아동들을 대상으로 주 2 회(회당 30 분), 총 8 주 동안 재활승마를 실시하였으며, 재활승마의 효과를 확인하기 위하여 재활승마 전(TR0), 4 주 후(TR1), 8 주 후(TR2)에 덴버 발달

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선별검사(DDST), 대 동작 기능평가(GMFM), 관절가동범위(ROM) 그리고 경직도 검사(ST)를 측정 하였다(실험 5).

DDST 의 결과, 재활승마 8 주 후에 DDST 의 개인-사회성발달은 재활승마 전에 비해 향상된 것으로 나타났으며, 재활승마 전과 후의 대 동작 기능 평가에서는 GMFM 차원 C(기기 및 무릎 서기), D(서기), E(걷기, 뛰기, 도약)에서 유의하게 향상되는 것으로 나타났다. 하지만 관절가동범위와 경직도 검사는 변화가 없는 것으로 나타나 16 회 기간의 승마운동으로 효과를 나타내기에는 다소 부족함이 있는 것으로 확인되었다. 또한 측정항목간의 연관성을 분석한 결과, 대 근육 기능의 발달은 개인성-사회성(PS), 소 근육 운동-적응성(FMA), 언어능력등과 상당한 연관성이 있는 것으로 확인되었다.

실험 4 에서는 지적 장애 아동들을 대상으로 재활승마를 실시하여 체력의 변화를 분석하기 위해 초등학교 특수 반에서 수업을 받고 있는 남아 세 명, 여아 세 명이 참여하였다(실험 6). 재활승마 프로그램 세션은 주 2 회, 회당 30 분씩 8 주 동안 제공 되었다. 각 참가자는 재활승마 전(T0), 8 회 후(T1), 16 회 후(T2)에 균형성, 협응성, 민첩성, 유연성을 측정하여 평가 하였다.

연구의 결과, 균형성 측정은 승마프로그램 전에 비해 균형을 더 오래 유지 시키는 것으로 나타났으며($p<0.01$), 협응성의 측정 비교에서도 재활승마 후가 재활승마 전에 비해 유의하게 향상되는 것으로 나타났다($p < 0.001$). 민첩성 측정 비교의 결과는 재활승마 후가 재활승마 전에 비해 개선은 되었지만 유의한 변화를 보이지 않았으며, 유연성 측정 결과는 재활승마 후가 재활승마 전에 비해 유의하게 향상되는 것으로 확인 되었다($p<0.5$). 따라서 재활승마가 지적 장애 아동들의 체력을 향상시키는데 효과적인 것으로 판단된다.

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이상의 결과를 종합해 볼 때, 본 연구의 결과는 제주산마의 수영훈련에 따른 긍정적 효과가 확인되었으며, 운동으로 피로해진 말들을 위한 적절한 휴식방법의 적용 방안을 제시할 수 있을 것으로 생각된다. 또한, 제주산마를 활용한 재활치료로 뇌성마비와 지적 장애 아동들의 동작기능과 운동체력의 개선에 이용할 수 있을 것으로 생각된다. 본 연구의 결과는 말의 운동능력 및 재활승마를 위한 기초 자료로 유용하게 이용될 것이라 사료된다.

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APPENDIX

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감사의 글

커다란 두 눈과 쫑긋거리는 큰 귀, 후려치는 꼬리와 벌름거리는 코---말~!!

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말과의 또 다른 만남 승마~!! 승마는 내 인생을 완전히 바꿔 놓을 만큼 크나큰 인생의 전환점을 만들어 준 계기가 되었습니다. 마흔 나이에 회계학 전공에서 생명공학 전공으로 바뀔 만큼 말과의 만남은 커다란 인연이 되어 새로운 내 인생을 설계하게 되었습니다. 그 전환점을 만들어 주신 분이 강민수 교수님이었습니다. 지도교수님이신 강민수 교수님과의 인연은 승마하면서 시작되었고, 학자의 길을 가고 계시는 부드럽고 자상한 교수님을 보면서 저도 새로운 학문의 길로 접어들게 되는 바탕이 되었습니다. 동물자원학과로 편입하여 지금껏 7년여 세월동안 많은 당근과 채찍으로 오늘의 저를 있게 해 주신 강민수 교수님께 머리 숙여 감사 드리며, 부끄럽지 않은 제자로 설 수 있도록 많은 노력을 다 하겠습니다. 그리고 언제나 힘내라고 격려를 아끼지 않으신 정동기 교수님, 웃는 얼굴로 통계분석처리지도를 해주시던 양영훈 교수님, 도움을 달라고 재촉하는 저를 위해 귀한 시간을 할애 해주신 류연철 교수님, 새로 부임해 오셔서 교육연구에 분주하신데도 통계분석 정리를 친절히 도와주시던 이왕식 교수님, 실험을 비롯한 심사위원으로서의 도움까지 주신 윤영민 교수님을 비롯하여 윤미정조교 선생님, 한경은 조교선생님, 김대수 조교선생님께도 감사 드립니다. 또한 심사위원으로 고생해주신 제주특별자치도 말육성팀 오운용 박사님께도 진심으로 고맙다는 뜻을 전하고 싶습니다. 더불어, 더할 나위 없이 동지가 되어 주었던 대학원생들 권태준, 배

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재호, 박준형, 임미진 그리고 고경보, 강동근, 황순회, 강용준 원우들에게도 고마운 마음 전합니다. 무엇보다 오늘의 학위논문이 완성을 위한 긴 시간 동안 귀중한 시간을 기꺼이 내어 재활승마 연구에 도움을 주신 김향안, 양효숙, 오상명, 김미경, 황정순을 비롯한 모든 자원 봉사자들과 참가자 여러분, 그리고 그들의 부모님들께도 너무나 감사 드리며, 장애우 교육실습 측정분석에 힘 써주신 늘봄 재활병원 문준원장님을 비롯하여 고수정 선생님께도 정말 감사 드립니다. 아울러 말과 장소 제공은 물론 자원봉사까지 서슴치 않고 도와주신 홀스타 동호회 이태연님과 관계자 여러분들에게도 너무나 감사 드립니다. 일일이 거명할 수 없지만 웰빙 승마클럽 김용언 회장님, 이승국 부회장님, 이영수 부회장님, 손정희 이사님, 오양순 이사님을 비롯한 여러 회원님들 그리고 제주대학교 웰빙 승마교실 모든 식구들에게도 진심으로 감사 말씀 전합니다. 그리고 사랑하는 나의 가족들, 늘 잠이 부족하고 휴식이 필요한 나에게 든든한 울타리로 편안히 쉬게 해주던 남편과 너무나 사랑하는 두 아들 경보와 경민이, 허허 웃으시며 언제나 버팀목이 되 주시고 저를 이뻐해 주시는 아버님, 어머님을 비롯한 모든 가족분들에게도 감사 드립니다. 그리고 강한 듯 보이지만 한없이 여린 나의 오빠들과 언니들, 하나밖에 없는 내 동생 태영이를 비롯하여 세 분의 올케들에게도 이 기회를 빌어 깊은 감사를 드립니다.

저는 지금 제 인생의 그 어떤 때 보다 가슴 뭉클합니다. 제 인생의 어떤 성공도 이보다 멋질 수는 없습니다. 아이들을 얻었을 때, 세상을 다 가진듯한 행복을 느꼈다면, 지금은 가슴이 벅차올라 가장 깊고 험한 산을 정복한 것처럼 심장이 뜁니다. 그것은 지금 힘들었던 시간들을 이겨낼 수 있었던 원초적인 힘을 주신 한 분 때문입니다. 그 한 분, 어머님~!! 한 평생을 고생만 하고 살아오신 나의 어머님, 그 많은 세월 눈물로 살아오신 어머님께 그 눈물이 헛되지 만은 않았다는

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걸 보여 드릴 수가 있어서 저는 지금 뜨거운 눈물이 흐릅니다.

사람은 배워야 살고 은혜를 모르면 짐승만도 못하다는 말씀을 귀에 못이 박히도록 하시던 어머님께 더 늦기 전에 소중한 박사학위모자를 씌워드릴 수가 있어서 너무나 기쁨입니다. 이 논문은 아버님을 먼저 멀리로 보내시고 외로이 계신 어머님께 막내딸이 그 동안의 고생에 조금이라도 보답하며 감사하는 마음으로 드리는 감사패입니다.

어머님~!! 당신이 계셔 제가 있습니다...어머님이 보여주신 높고 깊은 사랑이 제게는 어머님이야말로 진정 인생의 훌륭한 박사셨습니다.

어머님~!! 사랑합니다..!!!.

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