Intensive Therapy Combined with Strengthening Exercises Using the Thera Suit in a Child with CP: A Case Report ©

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Background and Purpose: Development of gross motor function in children with cerebral palsy has been a primary goal of physical therapist for decades. The purpose of this report is to describe how the Thera Suit combined with an Intensive Therapy Program, was used in a twelve-year-old boy diagnosed with cerebral palsy (CP). Methods: Prior to participating in the intensive therapy program with the Thera Suit he was classified using the Gross Motor Function Classification System and his gross motor abilities were measured with the Gross Motor Function Measure. The subject participated in intensive therapy with the Thera Suit for three weeks, Monday-Friday, 8:30 am -12:30 pm. In addition, to the program the boy also received a half an hour of aquatherapy and hippotherapy each of the weeks. At the conclusion of the three weeks, and after six months post intervention, the subject's gross motor abilities were measured with the Gross Motor Function Measure. Results: The subject demonstrated improvements at the conclusion of the three weeks in all categories of the Gross Motor Function Measure. The overall improvement from the baseline score was 8.66% without the use of assistive devices and 9.53% with assistive devices. The subject maintained these improvements when re-tested six months post intervention. Conclusion and Discussion: This case report suggests that the Thera Suit with the Intensive Therapy Program, including aquatherapy and hippotherapy, helps improve a patient's functional abilities. Also this case report supports the literature suggesting changing current physical rehabilitation

programs for children diagnosed with CP to include bouts of intensive suit therapy programs.

Key Words: *Thera Suit, Intensive Therapy, Cerebral Palsy, GMFM*

Over the past fifty years research into promoting motor development for children with Cerebral Palsy (CP) has focused on rehabilitation method, training method, or treatment method. However many of these studies have been inconclusive secondary to methodological bias or limitation such as small samples, inappropriate outcome measures, improper study design, or lack of standardization of experimental procedures.[1]

Recently there has been renewed interest in one of the more controversial rehabilitation methods: the use of strengthening exercises for children with CP. The controversy began with the old theory, established mainly by NDT/ Bobath trained therapists, which was based on the belief that strength training would increase co-contraction, spasticity, and associated movements thus interfering with motor control.[2,3] Because of this, many therapists are reluctant to use strengthening exercises for fear that they will increase the spasticity and produce abnormal movement patterns. Therefore, there are no currently accepted treatment techniques documented to be effective for strength training in children with CP. However, some research has shown that an increase in isolated strength does not increase spasticity. Fowler et al found no changes in spasticity following quadricep femoris muscle strengthening in children with CP.[4] MacPhil and Kramer also found no increase in spasticity as a result of the strength training program.[5] It has been documented that children with CP use excessive muscle cocontraction during voluntary movement, therefore, there is clinical concern for the potential for inadvertent strengthening of the spastic antagonist muscle during training of the agonist through persistent co-contraction or other neural mechanisms.[6] Howerver, Damiano et al found no change in hamstring strength as a result of strengthening the quadriceps.[7] The importance of muscle strength for children with CP can be seen in the direct relation between strength and motor function. For example, children with stronger knee extensors are more likely to perform better on gross motor skills, walk more quickly, ambulate with less knee crouch, and have greater economy when walking.[8] These are usually the primary goals of physical therapists treating children with cerebral palsy. MacPhail and Kramer's eight-week isokinetic strength training program resulted in a significant increase in peak torque, work and improvements in the children's Gross Motor Function Measure scores for adolescents with cerebral palsy.[5]

Another form of strength training is repeating functional tasks. By breaking down functional movements into simple tasks and repeating them, retention of the task can be increased. This is significant to children with cerebral palsy because it can help them develop new motor plans. Dean and Shepherd and Carr and Shephard have published two studies showing the retention of motor performance through the use of repetition of tasks.[9,10]

New methods of correcting motor control in neurological disorders are always of interest to medical personal and the general public. Just recently strength training has been influenced by the Russian researchers' introduction of the Space Suit. The Space suit is a modified version of the Russian cosmonaut's space uniform, the "Penguin", developed in 1971 to prevent the detrimental effects of hypokinesis in the weightless conditions of space.[11] In 2002 the Thera Suit[*] was developed. The basic concept was to create the

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exo-skeleton . Currently, the use of a therapeutic suit in the late residual stage of cerebral palsy allows patients with severe movement disorders to develop new modes of walking and to acquire new motor stereotypes more quickly.[12] The theory behind the suit therapy is that it induces a strong afferent proprioceptive input which stimulates the formation of cerebral systems whose post-natal development has been delayed.[11] The proprioceptive input is produced via a series of elastic/rubber cables that act like an exo-skeleton producing a vertically directed load of approximately thirty-three to eighty-eight pounds. The exo-skeleton produced by the suit theoretically increases the significant effects on the patients' ability to form new motor plans. Due to the ability to provide artificial formation and reinforcement of appropriate movement habits through the suit with repetitive exercises, patients learn the new motor plans and build strength at the same time. Because of the locomotor neurological component in combination with the strength training, it makes the suits ideal for various neurogenic movement disorders, especially cerebral palsy.

The TheraSuit in conjunction with intensive therapy treatment program focus on motor development, strengthening, endurance, flexibility, balance, and coordination. The intensive therapy treatment program consists of physical and occupational therapy for hours a day, five times a week, with the option of adding an additional half an hour of aquatherapy and/or hippotherapy each of the three weeks. The suit therapy is typically done within a four hour therapy session. Within these four hours the children are subjected to the universal exercise unit for transitional strengthening or isolated muscle strengthening. The universal exercise unit is a three dimensional metal cage with the addition of pulleys, cables, and weights can be used for different rehabilitation techniques. This new intensive therapy program has minimal research to prove its effectiveness; therefore, there is an immediate need for research studies.

METHODS

STUDY DESIGN

This is a single test retest case report using the Gross Motor Function Measure-88 (GMFM-88). A baseline measurement was taken to provide a basis for comparison with the new intervention. The GMFM-88 baseline measurement was scored two times: once without AFO's and assistive devices and a second time with AFO's and assistive devices. The GMFM is a criterion-referenced measure based on the concepts of abilities and limitations in gross motor function and is analogous to the staging and grading systems.[13,14,15,16] Currently there are two version of the GMFM: the original 88-item measure (GMFM-88) and the more recent 66-item GMFM (GMFM-66). The GMFM-66 is a subset of the 88 items in GMFM-88, which has been shown to be unidimensional.[17] The GMFM-88 consists of 88 items grouped into 5 dimensions: 1. Laying and rolling (17 items), 2. sitting (20 items), 3. crawling and kneeling (14 items), 4. Standing (13 items), 5. Walking, running, and jumping (24 items).[18] The GMFM takes approximately 45 minutes to administer. Both are clinical measures designed to evaluate gross motor function in children with cerebral palsy from birth to twelve years old. The Gross Motor Function Measure should be used when evaluating the functional level and/or gain in any child with CP because it is one of the only standardized tests that measures functional ability specifically for children with CP. The GMFM has shown to be reliable, valid, and responsive to change in gross motor function for children with CP.[13,14,15,16] In this case study the intervention following the baseline measurement included the intensive physical and occupational therapy for three weeks, four hours per day. Following the last treatment session the patient was retested again both with and without braces and assistive devices using the GMFM-88. The patient was also retested six months post-intervention.

This is a convenience single subject case report based on the diagnosis of CP. Cerebral palsy is defined as a disorder of movement and posture due to a defect or lesion of the immature brain present at birth or shortly thereafter. For practical purposes, it is useful to exclude from cerebral palsy those disorders of posture and movement which are 1. of short duration, 2. due to a progressive disease, 3. due solely to mental deficiency.[19] The subject was chosen on a volunteer basis. Parents of the participant signed an informed consent form and received a copy of the HIPAA guidelines.

CASE STUDY

HISTORY

The subject was a twelve year old male with the diagnosis of spastic quadriplegic cerebral palsy with a shunt. The subject's history was obtained from the mother. The subject's mother was induced at thirty weeks gestation secondary to toxemia for three days. Through testing at birth it was noted he had a grade-3 cerebral bleed and he was ventilated for two days after birth. The subject had a shunt surgically placed at 2 weeks old. He also has a history of kidney stones, eye surgery, and an un-descended testicle. Prior to this study the subject participated in four separate intensive suit therapy programs in Poland. Polish suit program is slightly different than the protocol for this case report. For example, the patient goes for six days a week versus the five days in this protocol and their daily treatments are 6 hours long with approximately one and half hours of breaks versus four hours with one fifteen minute break. At home the subject was receiving thirty minutes a week of educationally relevant physical therapy and thirty minutes a week of educationally relevant occupational therapy in the public school system. Educationally relevant therapy is designed to enhance the student's ability to benefit from special education or to gain access to regular education. In addition, he was receiving forty-five minutes twice a week of private physical therapy. His therapy treatments equal two and half hours of combined OT and PT per week.

His initial GMFM-88 baseline is broken down into the categories listed in Table 1. The subject's Gross Motor Function Classification System for Cerebral Palsy (GMFMCS) is a level IV for the group between 6^{th} and 12^{th} birthdays. For each description of the classification refer to Table 2. The GMFMCS is based on the concepts of abilities and limitations in gross motor function and is analogous to the staging and grading systems used in medicine to describe cancer. [18]

INTERVENTION

The subject received three hours of physical therapy (PT), half an hour of occupational therapy, and half an hour of massage therapy (by a PT or massage therapist) per day. The physical therapy was administered by three physical therapists that were all trained and certified in the intensive therapy, universal exercise unit, and the Thera Suit. All the physical therapists utilized NDT techniques, development sequence training, gross motor training, gait training, balance and coordination training, range of motion (ROM) and strengthening techniques. The rehabilitation program also included occupational therapy which focused on the upper-extremity function (manipulation, prehension, strengthening, ROM, hand-eye coordination tasks, and perceptual training). For the subject's specific three week schedule refer to Table 3.

During the three weeks of treatment, part of the program included an hour in the universal exercise unit (UEU)[†], also known as the "monkey cage" and the "spider cage." The UEU is pictured in figure 2 and 3. The monkey cage (figure 2) uses the UEU with a system of pulleys and weights to isolate muscle groups and allow for strengthening without compensating with other muscle groups. The spider cage (figure 3) uses the UEU with a system of eight elastic/bungee cords attached to a waist belt. This system allows the patient to experience more independent movements, weight shifting, and assisted movements such as sit to stand, quadruped, squats, and jumping. The therapist guides the child through exercises to strengthen muscles and allow the patient to experience movements.

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In addition to the three week intensive therapy, the subject also participated in Hippo and Aqua therapy. The subject received a half an hour of each therapy each week during his three week program. Hippotherapy is a type of therapy that utilizes the movement of a horse's gait pattern while a physical and/or occupational therapist treats the patient. The movement of the horse's hind legs and pelvis is transmitted to and produces movement in the pelvis of the human when sitting on the horse. The patient can ride backward, sideways, kneeling, quadruped, or standing. It is also an excellent tool for head, neck, and trunk strengthening, balance, and overall endurance. Hippotherapy has been shown to improve gross motor function in children with cerebral palsy.[20] Aquatic therapy uses the principles of water to assist in the therapy. The water allows the child to experience ease of movement and greater range of motion and also provides resistance to allow for strengthening. The movement and swimming exercise program has a better effect on vital capacity than a physical therapy routine consisting of respiratory exercise alone.[21]

RESULTS

BASELINE PHASE

Table 2 illustrates the total GMFM-88 scores for each category recorded at the initial evaluation (Time 1). The total number of treatments between the baseline and the re-evaluation is fourteen four hour days, for 59 hours of therapy. A detailed breakdown of these days can be seen in table 3.

EXPERIMENTAL PHASE

The subject participated in the intensive suit therapy program at a specialty pediatric out-patient practice in South Florida from 8:30 am to 12:30 pm (refer to table 3). The subject followed the program with 100% compliance. During the three weeks of intervention, the subject received fifty-nine hours of combined therapy. Following the treatment on the last day, the subject was re-tested with the GMFM-88. The re-test (Time 2) was conducted once with and once without AFO's and assistive devices (AD). The improvements for all the categories can be seen in Table 4. The subject then returned six months post-treatment to begin another three week intensive therapy program. At this time the subject was re-evaluated (Time 3) with the GMFM-88 to shown the patient's functional level and compare his current GMFM scores to the prior two measurements. Refer to table 5 for the six month re-evaluation scores. In figures 4, 5, and 6 the baseline evaluation is compared to the two re-test evaluations for each of the different test situations. When comparing the Time 1 score to the Time 2 score it shows an increase in the subject's GMFM scores in each category as well as an increase in the overall total score. At the completion of the three week intense therapy program note that significant improvement of performance was found in all the GMFM categories as well as the overall score. Six months post-intervention the patient maintained the progress made at the time of completion of the intensive program. This is demonstrated by the total score changing slightly. The total score increased slightly when compared to the previous scores. The subject demonstrated slight improvements in lying and rolling, crawling and kneeling, and walking, running, and jumping categories as compared to the baseline and retest at three weeks measurements. There was a minor decline of scores at the six month retest in the categories of sitting and standing. However, the category of standing without AD is the only category of the ten possible categories to fall below baseline.

DISCUSSION

There are three explanations to the improvement. They are 1. The intensity of the programs (20 hours of therapy a week including aqua and hippotherapy), 2. The use of the Thera Suit and the UEU, or 3. The combination of the intensity of the program, the Thera Suit, and the UEU. Results of this case study suggest the effectiveness of an intensive rehabilitation program comprised of the intensive suit therapy with the UEU. However, future studies will need to be conducted to exactly demonstrate which explanation yields the most significant results. Notably, this case report suggests that patients that participate in the three week intensive therapy may maintain their achievements for at least six months post-intervention. These results support the outcomes of a similar study by Trahan and Malouin the gains achieved by a short intensive therapy program without the suit were maintained.[1] In their study the GMFM was used to demonstrate that forty-five minute treatment session, four times a week for four weeks increased the subjects' GMFM scores. Then the second portion of their study demonstrated that the subjects maintained the score increases during an eight week rest period without any involvement in any type of therapy.[1] Therefore the subject is predicted to maintain the gains based on Trahan and Malouin study.[1] However, in this case report, the intensive program recommends a week off from any therapy and then continuation of the subject's previous therapy schedule with the addition of a home exercise program from the intensive therapists to promote the improvements made during the program. The home exercise program for this patient included ten core exercises and stretches for the family to do at home. The family was verbally instructed with demonstration before the end of the three weeks. Also, the family received a written set of instructions with illustrations.

The findings in this case study appear to validate the results of Trahan and Malouin's study suggesting the need to increase treatment frequency in order to significantly improve the level of motor performance. [1] Studies by Mayo, Bower and McLellan, Bower et al, and Richards et al also support the fact that intensive therapy can accelerate motor performance in children with cerebral palsy. [22,23,24,25] However, further research is needed to determine weather the addition of the therapeutic suit to the intensive program achieves higher GMFM scores.

The basis of the intensive suit therapy program is increasing motor performance through strength training and repetition of meaningful tasks while using the Thera Suit or UEU. Strength training in children with cerebral palsy has been controversial secondary to the fear of increasing spasticity and abnormal movements. However, new studies provide results suggesting that strength training exercises in children with cerebral exercise do not interfere with motor control. [5,4,8,6,7] Dean and Shepherd and Carr and Shephard have published two studies showing the retention of motor performance through the use of repetition of tasks. [9,10] This study provides increasing support for strength training and an intensive therapy program.

LIMITATIONS OF THE CASE STUDY

The intensive suit therapy program has some advantages and disadvantages. The most significant advantage is the increase in the GMFM scores for the child. This can lead to an overall improvement in the quality of life and an increased independence for the child. The results support that a child will maintain the levels achieved following the intensive intervention further suggesting they will be able to maintain or improve upon the increases in functional gains to increase the child's independence. Another advantage is the interaction and communication between the therapist, the child and the family. Being able to interact with the child and the family for extended periods of time on a daily basis has a positive effect on the rehabilitation process for the child and an overall positive therapeutic effect for the child and the family. The main disadvantage to this program is the time required. The patient and family must commit to block out three weeks at four hours per day to attend the treatment program. Also, most families must travel to clinics that are specialty trained and certified in the use of the Thera Suit and UEU. Families also must factor in travel time and vacation time from work and/or school. Another disadvantage is the cost involved. The new intensive suit therapy program is rarely covered by insurance, therefore causing parents to pay out of pocket for the therapy in addition to the travel and lodging. Insurance companies might begin to cover portions of the therapy program if there were more reliable research published regarding its efficacy.

Insurance coverage is just one example of the need for further research. A few other examples can be addressed by the limitation of this study. The first limitation is the small number in the sample size. Because this was a single subject case report, it is hard to apply the results to the entire population of children with cerebral palsy, especially because of the different functional levels of each child. Another limitation is not having a control group. Without a control group the natural variation of motor performance cannot be controlled.

Another limitation to this case study is the fact that it is still unclear if the increase of GMFM scores is due to the intensive therapy program (5 days/week * 4 hours per day, including aqua and hippotherapy), the Thera Suit and UEU, or the combination of the intensity, the suit, and the UEU. This suggests the need for more detailed studies to be conducted to determine what will have the greatest impact for children with cerebral palsy. The overall goal is the help the children become as functionally independent as possible therefore creating the need to determine how to achieve it in the most effective way.

There were also a few external influences that might have affected the subject's performance. This was the fifth time the subject has participated in the intensive suit therapy program. However, the first four times the patient traveled to the clinic in Poland. As mentioned previously, their suit program is slightly different. Also at the time of the patient's re-evaluation, he had just finished his last four hours of treatment. The patient was already showing signs of fatigue which might have interfered with the subject's ability to perform at his best possible ability and achieve a higher GMFM score. In addition to the fatigue, the patient was also complaining of right foot soreness and right shoulder soreness. Both were evaluated by one of the treating physical therapists, to be a mild contusion to the right foot and muscle fatigue of the right shoulder. The pain of either might have limited the patient's ability to perform at his maximum potential.

CONCLUSION

In conclusion, this case report warrants the need for more research in order to generalize the suggestion of this report: that children with cerebral palsy may be able to make significant improvements in their motor performance when participating in the intensive suit therapy program. However, this study, along was the others, supports the change of current physical rehabilitation programs to include bouts of intensive suit therapy. [1,22,23,24,25] Accordingly, because this patient's improvements were acquired form all therapies, the intensive therapy program, the suit, the UEU, aquatherapy, and hippotherapy should be recommended for optimizing the patient's best ability to make functional improvements. The changes would provide the best treatment regimen to optimize the motor performance, quality of life, and functional independence in a child with cerebral palsy.

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Figure 1 – Thera Suits

Figure 2 – UEU "Monkey Cage"

Figure 3 – UEU "Spider Cage"

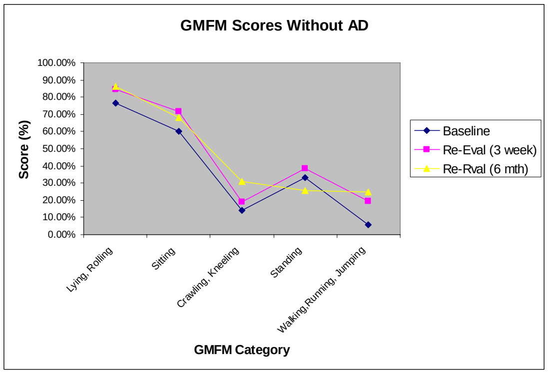

Figure 4 – GMFM Socre Without Assistive Devices

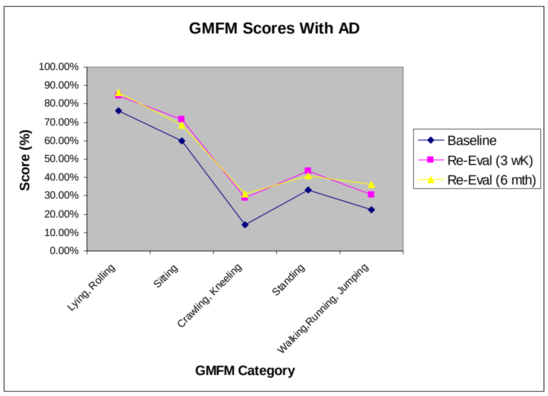

Figure 5 – GMFM Scores with Assistive Devices

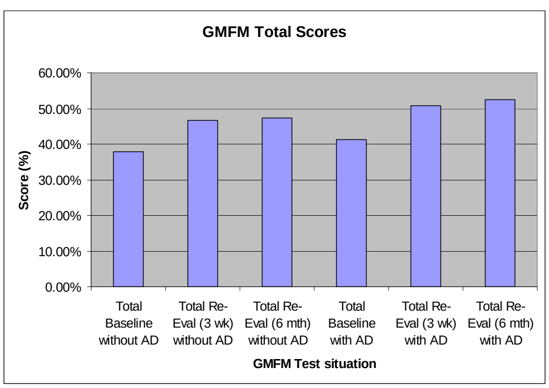

Figure 6 – GMFM Total Scores

TABLE 1 Gross Motor Function Classification System For Cerebral Palsy[16]

Level I	Children walk indoors and outdoors, and climb stairs without limitations. Children perform gross motor skills including running and jumping, but speed, balance and coordination are reduced.
Level II	Children walk indoors and outdoors, and climb stairs holding onto a railing, but experience limitations walking on uneven surfaces and inclines, and in crowds or confined spaces. Children have at best only minimal ability to perform gross motor skills such as running and jumping.
Level III	Children walk indoors or outdoors on a level surface with an assistive mobility device. Children may climb stairs holding onto a railing. Depending on upper limb function, children propel a wheelchair manually or are transported when traveling for long distances or outdoors on uneven terrain.
Level IV	Children may maintain levels of function achieved before age 6 or rely more on wheeled mobility at home, at school and in the community. Children may achieve self-mobility using a power wheelchair.
Level V	Physical impairments restrict voluntary control of movement and the ability to maintain antigravity head and trunk postures. All areas of motor function are limited. Functional limitations in sitting and standing are not fully compensated for through the use of adaptive equipment and assistive technology. Children have no means of independent mobility and are transported. Some children achieve self-mobility using a power wheelchair with extensive adaptations.

TABLE 2 Baseline Measurement

Category	Without AFO's and AD	With AFO's and AD
Lying and Rolling	76.47%	76.47%
Sitting	60.00%	60.00%
Crawling and Kneeling	14.29%	14.29%
Standing	33.33%	33.33%
Walking, Running and Jumping	5.56%	22.22%
Total	37.93%	41.26%

TABLE III

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:30	HP*/SB**	HP/SB	HP/SB	HP/SB	HP/SB
8:45	Massage	Massage	Massage	Massage	Massage
9:00	Stretch	Stretch	Stretch	Stretch	Stretch
9:15	Trunk Exercises	Trunk Exercises	Trunk Exercises	Trunk Exercises	Trunk Exercises
9:30	Monkey	Spider	Monkey	Spider	Monkey
9:45					
10:00					
10:15					
10:30	UE	UE	UE	UE	UE
10:45	UE	UE	UE	UE	UE
11:00	Break	Break	Break	Break	Break
11:15	Suit-up	Suit-up	Suit-up	Suit-up	Suit-up
11:30	Suit	Suit	Suit	Suit	Suit
11:45					
12:00					
12:15					
12:30	Done	Done	Done	Done	Done
	Hippotherapy				Aquatherapy

*HP = Hydroculator Pack
**SB = Sands bags

TABLE 4 Re-Evaluation

Category	Without AFO’s and AD	Change	With AFO’s and AD	Change
Lying and Rolling	84.31%	+7.84	84.31%	+7.84
Sitting	71.67%	+11.76	71.67%	+11.76
Crawling and Kneeling	19.05%	+4.76	23.81%	+9.52
Standing	38.46%	+5.13	43.59%	+10.26
Walking, Running and Jumping	19.44%	+13.88	30.56%	+8.34
Total	46.59%	+8.66	50.79%	+9.53

TABLE 5 6 Month Re-Evaluation

Category	Without AFO's and AD	Change (BL)	Change (RE)	With AFO's and AD	Change (BL)	Change (RE)
Lying and Rolling	86.27%	+9.8	+1.99	86.27%	+9.8	+1.99
Sitting	68.33%	+8.33	-3.34	68.33%	+8.33	-3.34
Crawling and Kneeling	30.95%	+16.66	+11.9	30.95%	+16.66	+7.14
Standing	25.64%	-7.69	-12.82	41.05%	+7.22	-2.54
Walking, Running and Jumping	25.00%	+19.44	+5.56	36.11%	+13.89	+5.55
Total	47.24%	+9.31	+0.65	52.54%	+11.28	+1.75