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The Effect of PNF Hamstring Stretching on Speed

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Chapter 1 – Introduction

Speed is a function of time and distance. It can be defined as the ability to produce a specific movement very quickly (Prentice, 2004). It is one of the necessary components for successful performance in many sports. Speed is a motor skill that can be enhanced with proper training (Plisk, 2008). Strength training and exercises such as plyometrics are used to increase explosiveness and over all athletic performance (Darden & Coker, 1996). In efforts to reduce injury risk in athletes and increase range of motion (ROM), stretching is also applied in and out of season during training programs (Wilmore, Costill, & Kenney, 2008). The present study utilizes the method of proprioceptive neuromuscular facilitation (PNF) stretching to examine the impact of hamstring flexibility on speed in females. The hamstrings are responsible for knee flexion and hip extension; therefore they play a powerful role in the running process. Because of the universal necessity for speed in many athletics, exploring ways to increase the optimal functioning of joints like the knees and hips is quite valuable.

The delimitations of the present study were relatively narrow. Sixteen healthy, young-adult, female athletes between the ages of 18-21 were examined. The subjects were evenly divided into control and experimental groups. All 16 subjects ran two, 20-yard dashes on day 1 of the research project and again on day 5. The experimental group underwent 3 consecutive days of PNF hamstring stretching in between sprints, while the control group had no stretching requirements. Only contract relax (CR) technique of PNF stretching was used during the study. The independent variable was the stretching technique, and the dependent variable consisted of individual speed measured during the 20-yard dashes. A standard stopwatch was used in the same gymnasium for all subjects. Speed testing trials and stretching sessions lasted approximately the same time for each subject and were conducted at about the same time of day.

Various limitations were also recognized in the study and are important to note. A limited number of college female subjects were tested, resulting in a small population sample size. In terms of the research method, simply 2 sets of 10 repetitions of PNF stretching for 3 consecutive days may not have been enough to adequately produce increased flexibility in individuals. More stretching may be required to attain enough flexibility to show changes in speed, for example stretching 3-5 days for a 2-3 week period before the final speed trials. Furthermore, uncontrolled variables such as diet, rest, muscle soreness, comfort level, or fatigue from PNF exercises may have impacted the results. An abnormal amount and intensity of exercise by the control group during the 3 days in between tests could have increased flexibility and thus impacted the data of their second trials. Additional uncontrolled variables were inconsistencies such as lack of precision with starting and stopping the stopwatch at exactly the right moments, which may have affected the sprinting times.

Assumptions were made that the subjects put forth maximal effort during the tests and honestly and accurately completed the questionnaires. The hypothesis allotted to the present study was a directional hypothesis, where a predicted difference in results is stated and explained. The prediction was that there would be a difference in sprinting speed between day 1 and day 5 in the experimental group alone, where an increase in flexibility from stretching would increase speed. However, although this direct relationship between PNF stretching and speed is expected, the methods of the study may not have been sufficient to yield valid results.

The current study is important because of the common requirement for speed in athletics. Finding ways to increase speed is valuable to both players and coaches when trying to find ways to advance performance. Exploring the additional benefits of PNF stretching is also worthwhile because of the prevalence of issues within the body such as pain, instability, and injuries as a whole. PNF stretching is designed to maximize improvements in flexibility which aid in preventing or recovering from these issues. Finally, speed and flexibility pertain to assisting the vast majority of the population regardless of age, gender, or athletic skill level.

Chapter 2 – Review of Literature

Speed and flexibility have largely been studied as separate topics of interest. Although numerous literature reviews were found on PNF stretching, the effect it has on speed in individuals seems to remain inadequately explored. The importance of speed is investigated for various ways to measure it, as well as develop improvement. Information regarding injuries relevant to the present study is investigated. Some of the different popular hamstring stretching techniques and the benefits yielded by performing them, such as decreased back pain and increased functionality, are discussed. Thus the importance of flexibility for optimal performance is emphasized.

According to Darden and Coker (1996), speed is an important focus for coaches when training athletes to respond quickly to external stimuli. Most sports require a fast reaction time, such as sprinting, swimming, wrestling, and football. The authors specifically discuss sprinting, and the various focus points trained in athletes for the quickest reaction time (RT). However for increasing speed, the most important training is explained as a combination of efficiency in RT and movement time, in other words total response time. Extra emphasis is placed on movement time, especially for less experienced athletes. Although instruction differs and is adjusted according to the athlete's experience level, achieving full stride is the most important element and can be attained through proper technique training.

Olmo and Castilla (2005) measured strength in individuals to specifically examine explosiveness in sporting activities. Male and female subjects consisting of 41 high-intensity long-distance runners and 65 high-intensity sprinters were tested by isokinetic knee flexion and extension exercises. Dominant limbs were tested during 3 repetitions at 60°/sec speed and 15 repetitions at 300°/sec. Researchers found that RPI (Relative Power Index) for hamstrings was superior to quads. RPI was also found higher in sprinters versus long-distance runners. The possible explanation given for these results was the elevated amount of Type II fast-twitch muscle fibers in the hamstrings of track athletes who sprint rather than run for endurance. The authors recommended the studied parameters for measuring explosive power in relation to sprinting in athletics.

Variables impacting maximal running speed were researched in a study by Babić, Harasin, and Dizdar (2007). Seven power variables and 12 morphological character variables were explored in relation to stride length and frequency, flight duration, and foot-ground contact duration during maximal running in 133 male students between ages 19-24. Canonical analysis belongs to the statistical group of regression methods and is a way of evaluating data. This form of analysis was used to determine the statistical relationship, or correlation, between kinematic parameters and power and morphological factors. Under the first canonical analysis, longer strides were observed in subjects with larger skeleton dimensions, lower fat percentage, and advanced relative power. The second canonical analysis showed that subjects with larger skeleton dimensions yielded decreased stride frequency with longer lasting foot-ground contact. An inverse relationship was detected between stride length and stride frequency during maximal running speed. The data collected from this study may be helpful in analyzing factors impacting sprint performance in non-elite runners, as well as provide insight into efficiency mechanisms for maximal running speed.

The hamstring musculature plays an important role in running, but unfortunately hamstring injuries are common in athletics and have a rather high recurrence rate. Sole, Milosavljevic, Sullivan, and Nicholson (2008) explored the hamstring muscle group function through a neuromuscular approach. EMG studies were conducted to specifically examine core muscle patterns during gate analyses. Researchers found that stability loss in joints distal and proximal to the hamstrings (lumbo-pelvic articulations and the knee) increased risk for hamstring injury. Decreased strength and/or flexibility were also explained as a possible cause for hamstring injury. Further research needed to be conducted to confirm whether hamstring injuries are also associated with altered muscle recruitment. In addition, the authors noted that footwear effect on hamstring function was also lacking research. In conclusion, the authors noted that the most significant information regarding the risk of hamstring injury was connected to joint instability surrounding this musculature.

Further research on hamstring injuries was depicted in a longitudinal case series study by Askling, Tengvar, Saartok, and Thorstensson (2007). The study examined 18 elite sprinters by clinical evaluation and MRI who had sustained acute hamstring strains for the first-time. Subjects were evaluated during days 2-4, 10, 21, and 42 after injury, as well as 2 years later for follow-up. Assessments included observance, functional tests, palpation, resistance exercises, and interviews with the subjects. The same specific rehabilitation program was performed by each athlete between the 42 day and 2 year follow-up examinations. Results showed that after hamstring injuries, palpation during the first 3 weeks and MRIs during the first 6 weeks offer helpful information regarding the predictable time for elite sprinters to be able to resume original level of performance.

Maintaining full ROM is an essential part of athletic fitness and sport performance. Consistent stretching is important because flexibility is lost rather quickly with inactivity (Wilmore, 2008, p. 312). Anatomical factors that can limit joint mobility are: bony structures (end point restriction for example), connective tissue (such as ligaments), muscles and their tendons, skin (scarring for example), and fat (Prentice, 2004, pp. 122-123). Although opposites, agonist and antagonist muscle groups balance in unison to provide joint stability and coordination during movement. The agonist group is responsible for muscle contraction; for example, quadricep muscles during knee extension. The antagonists are relaxed and stretched in response to the contraction from the agonists; for example, hamstring muscles during knee extension (Prentice, 2004, p. 124).

The different stretching techniques used during rehabilitation are ballistic, static, PNF, myofascial, and neural tissue stretching. PNF exercises are stretching techniques used to increase both passive and active ROM. According to Sharman (2006), PNF stretching is deemed by literature as the most effective means for increasing ROM, particularly active PNF stretching. Contract-relax, hold-relax, and slow reversal-hold-relax are the 3 different types of PNF stretching. These techniques incorporate a combination of isometric or isotonic muscle contractions accompanied by relaxation to improve flexibility. PNF exercises exploit inhibitory reflexes in the body to increase relaxation of the muscles which, in turn, permits a greater stretch magnitude. The technique and pattern of these stretching exercises are efficient in how they allow muscles to perform actions similar to the movements found in many sports (Kofotolis, 2006). Contract-relax (CR) was the specific method of PNF stretching used in the present study because of its act in warming up the muscles while increasing ROM. This method is performed first by passive stretching to the point of limitation, and then applying resistance while the individual is instructed to push by contracting throughout the ROM until the original position is assumed (Prentice, 2004, p. 126).

Increasing flexibility is one of the common preventive and rehabilitative techniques for injuries to structures such as the hamstrings. Decoster, Scanlon, Horn, and Cleland (2004) conducted a study where a comparison was made between the flexibility effectiveness of standing versus supine hamstring static stretching. Data was taken from 29 male and female subjects by measuring active knee extension during hip flexion at 90° using a goniometer. Measurements took place before and after stretching, 3 days a week (3 repetitions of 30 seconds each) for 3 weeks. The stretching methods were randomly assigned to each of the subjects' legs; all participants engaged in both stretches. The standing stretch was conducted by subjects placing one foot on a table, hands behind their hips, and flexing forward maximally at the hips. The supine stretch was performed by one foot being placed up on the wall (in a door frame), the other flat on the floor, and distance adjusted appropriately according to stretch limits. Researchers found that the 2 different stretching techniques did not demonstrate significantly different results, nor did they differ significantly between genders. Both ways of stretching were found to effectively increase flexibility.

Additional research on hamstring flexibility was conducted by O'Sullivan, Murray, and Sainsbury (2009). The study was designed to observe short-term effects on hamstring flexibility from warm-up, static, and dynamic stretching on previously injured and uninjured subjects. 18 athletes with specific previous hamstring injuries participated, along with 18 similarly matched volunteers, but without the specific previous injury history, acting as a control group. Flexibility was examined over 2 days with 10 days max between tests, using a goniometer during passive knee extension. Warm-up consisted of a 5 minute jog. Static stretching was conducted exactly like the standing stretching explained in the previous study. And for dynamic stretching, subjects actively swung their legs in hip flexion and back to slight hip extension, while maintaining knee extension for 30 seconds. Baseline measurements were taken and 15 seconds of rest was required before post-stretching measurements. Results revealed that there were no significant differences between groups. Hamstring flexibility increased after warm-up and static stretching, but decreased after dynamic stretching.

With more relevance and similar principles to the present study being discussed, Kofotolis and Kellis (2006) researched PNF stretching effects on core endurance, functional performance, and flexibility in females suffering from CLBP (chronic low back pain). Eighty-six women were organized according to three random groups consisting of combination of isotonic exercises (COI), rhythmic stabilization training (RST), and control programs. COI is a form of PNF exercise focusing on controlled purposeful movements, where as RST is described as a PNF technique by isometric exercises where the instructor does not break the contraction. For 4 weeks the subjects were trained 5 times a week under their program, working on core stability and strength improvement. Researchers measured lumbar ROM and core muscular endurance before and after training, and 4 and 8 weeks following. Severity of back pain and inability were also recorded. Results revealed significant improvement in muscular endurance, function ability, and lumbar mobility, as well as a decrease in subjects' back pain from PNF exercises.

Johnson and Johnson (2002) also examined the impact of PNF stretching on the body, specifically for lumbar spinal instability. The authors explored the philosophy, history, procedures, and basic principles of the PNF technique in detail, even discussing the important involvement of verbal and visual stimuli. They explain how every piece of PNF stretching plays a role in the all around development of coordinated trunk and extremity control in the body. This is important information regarding the present study at hand, because of the significant role coordinated trunk and extremity control plays in fast and efficient sprinting. The authors reveal that the PNF approach can be used to enhance mobilization of restricted joints and soft tissues, train musculature for stabilization, facilitate appropriate firing patterns in muscles, and for training over-all efficiency in functional activity performances.

Brughelli and Cronin (2008) researched mechanical stiffness by the 3 directly measureable types during running: vertical, leg, and joint stiffness. The author explained the importance of understanding the body's musculoskeletal system and how it operates like a spring during the process of running. After extensive research, the authors provided guidance on ways to enhance running performance through training, but are left with ambiguity as to the relationship between running and stiffness due to the lack of sufficient literature on this topic. Therefore, information as to the optimal method for changing stiffness to improve running performance is speculative.

Muscular power has been discussed as a critical component of speed, and stretching has been thoroughly explored for its different ways to increase mobility, however the correlation between sprinting and flexibility is still speculative. PNF stretching has demonstrated improvement in increasing joint ROM and control, as well as muscular functionality altogether. These techniques are only helpful in improving performance and would seem, for that reason, to aid in improving running speed, however additional studies must be found to support this hypothesis.

Chapter 3 – Methodology

The research project was approved by the Manchester College Institutional Review Board prior to any testing. The data was collected by an independent groups design. Sixteen healthy, college, female volunteers were tested between the ages of 18-21. All subjects had previously participated in at least one year of high school or college sports, and were thus considered athletes to various degrees. Informed consent papers were signed by all participants prior to any testing procedures. Each subject also individually completed a simple questionnaire before being tested. The questionnaires were designed to detect and record variables that could impact the test results. Participants were asked their ages, current enrollment year at Manchester College, what sport(s) they played in high school and/or college and when. If any individuals had suffered from a significant injury, or were currently recovering from one, they were asked to describe what the injury was and when it happened. However, no participants had injuries or were undergoing treatment that would have affected results. They were also asked to briefly explain on paper their current exercise schedules on an average weekly basis. The subjects wore shorts in order to allow full ROM capability and were asked to wear the same shoes during separate testing times to further reduce possible variables.

The 16 volunteers were evenly split up into 2 groups so that a control group (8) and an experimental group (8) were each formed. Two separate speed testing days were scheduled 5 days apart. All 16 subjects were timed individually during two, 20-yard dash sprints on day 1 and on day 5. The control group of 8 participants was left unattended between the days of timed sprints. The experimental group members underwent 3 consecutive days of PNF hamstring stretching. A standard stopwatch was used during the sprints and each performance was done in the same indoor gymnasium. The speed test times of the two different days ranged from about six to ten o'clock in the evening, according to the availability of the subjects. Throughout the testing the gym remained an isolated and distraction-free environment.

Contract-relax (CR) was the only method of PNF stretching used, performing 2 sets of 10 repetitions with each leg. The subjects assumed a supine position while the instructor assisted in passive hip flexion to stretch the hamstrings to the maximal point. During each set the participants were told to announce when the limit of stretch was reached. The passive stretch was held for 5 seconds and participants were then instructed to contract their hamstrings, pushing against the resistance applied by the instructor until the involved limb reached the floor. Immediately after their leg reached the floor, subjects were told to relax and allow passive hip flexion stretching to be performed again. The participants kept track of repetitions while the instructor articulated when to contract and when to relax during each set. All stretching sessions took place in the same quiet, isolated, and distraction-free environment of the instructor's dorm room. Similar to the timing of the sprints on days 1 and 5, the 3 consecutive sessions of stretching took place in the evening times with each subject.

Minor variances in test performing times were due to inflexibilities of schedule. In attempts to decrease the amount of variables, the participants were asked to keep their exercise and eating schedules similar on days 1 and 5 of timed dashes; the majority of subjects yielded to these requests. During sprinting and stretching trials, any noticeable variables that could have influenced the results were recorded. Examples of variables during the tests would be, distractions in the gym or stretching room, physical and psychological well-being of the subjects, muscular soreness or tightness, and perceived effort from the subjects. A confidence interval of .05 was established a priori for the two-tailed Student's t-test in order to determine if significant statistical differences existed between the experimental and control groups.

Chapter 4 – Results

The following tables display data for each of the 16 subjects' average 20 yard dash times in seconds. Table 1 shows the results of the experimental group, while Table 2 displays the control groups' data. The columns of "Time difference" reveal the speed change between the 2 different days of tests.

Table 1 – Experimental group

Subjects	Day 1 (sec) (average of 2 sprints)	Day 5 (sec) (average of 2 sprints)	Time difference
Subject 1	4:16	4:11	0:05
Subject 2	4:22	4:08	0:14
Subject 3	4:16	3:79	0:37
Subject 4	4:55	4:41	0:14
Subject 5	4:11	4:26	- 0:15
Subject 6	4:38	4:65	- 0:27
Subject 7	4:34	4:44	- 0:10
Subject 8	4:08	4:25	- 0:17

Table 2 – Control Group

Subjects	Day 1 (sec) (average of 2 sprints)	Day 5 (sec) (average of 2 sprints)	Time difference
Subject 1	4:19	4:13	0:06
Subject 2	4:52	4:36	0:16
Subject 3	4:19	4:08	0:11
Subject 4	4:30	4:28	0:02
Subject 5	4:61	4:66	- 0:05
Subject 6	4:69	4:75	- 0:06
Subject 7	3:97	4:05	- 0:08
Subject 8	4:60	4:63	- 0:03

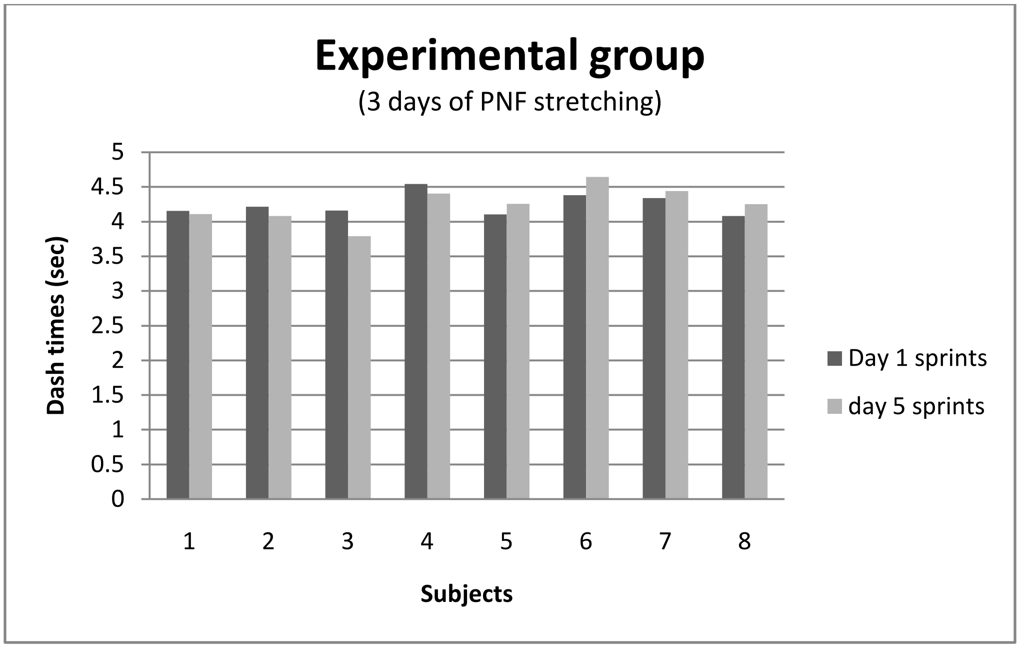
The following tables show results from the two-tailed Student's t-test that was used for hypothesis testing. An independent samples t-test was run for repeated measures. Group 1 represents the control group, while group 2 represents the experimental group. The 2 graphs following the tables provide a visual representation for comparison of the different speeds for each subject between day 1 and day 5.

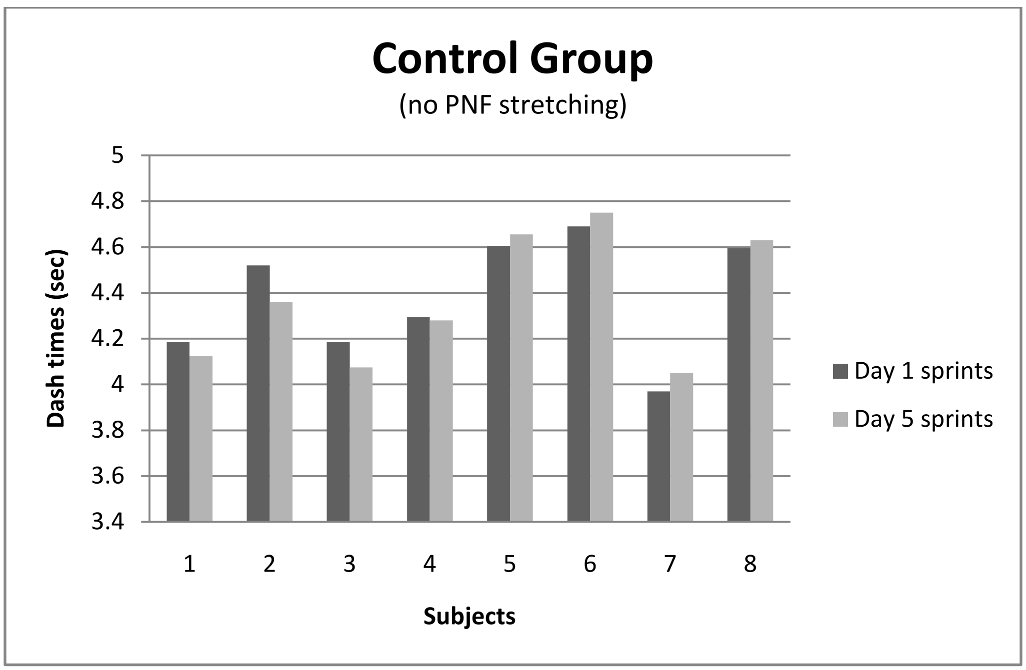
Group Statistics

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Differences	1	8	.016250	.0870037	.0307605
	2	8	.001250	.2114195	.0747481

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Differences	Equal variances assumed	7.025	.019	.186	14	.855	.0150000	.0808300	-.1583630	.1883630
	Equal variances not assumed			.186	9.305	.857	.0150000	.0808300	-.1669411	.1969411





Chapter 5 – Discussion

The present research study results demonstrate that statistically significant speed improvement after PNF stretching did not occur. Four out of 8 subjects from the experimental group showed increases in speed after the 3 consecutive days of stretching. However, 4 out of 8 subjects from the control group also showed improvements in speed *without* the PNF stretching. According to the two-tailed Student's t-test, t_{obt} value was less than t_{crit} value. Analysis reveals that there was not a significant difference within the group, and therefore the null hypothesis was confirmed. Previous literature reviewed during the project did not parallel the study, thus comparing methods and results was not available.

Variables such as footwear, days in between tests, testing times, and stretching times remained relatively consistent to eliminate additional variables. However, the limitation of the small sample size, as well as the numerous uncontrolled variables, may have significantly impacted the results, decreasing the reliability of the research study. If the study should be replicated, the following limitations and variables are factors researchers may want to consider. Variables such as the participants' comfort levels, muscle soreness or fatigue from PNF exercises, diet, and rest were not controlled, which may have slightly affected the results. Possible lack of consistent, maximal effort from the subjects is an uncontrollable variable that could have played a major role in the timed outcomes. Perhaps for more reliable results, male and female subjects should have both been selected, and the intensity and frequency of exercise engaged in during the week in between tests should have been monitored.

Additionally, the limitation of only 3 days of PNF stretching in between days 1 and 5 of timed sprints may not have been enough to gain reliable and adequate flexibility. If PNF stretching had been conducted for 3-5 different sessions during 2 or 3 weeks in between tests, significant increase in flexibility may have occurred, with a causal increase in speed. But the most problematic variable seemed to be the timing system during the sprints. Only one instructor ran the stop watch and recorded the information. During 2 different sprinting sessions the stop watch malfunctioned and the subjects had to re-run for a third sprint. Failure to appropriately see when the participants' feet crossed the marker to start the sprint may have caused slightly inaccurate and inconsistent speed times. If the study should be repeated, a more accurate system for timing sprints is advised for collecting more precise data results.

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Questionnaire

Name:______________________________
Age:____
Year at Manchester:______________
(If possible, please wear the same shoes for both testing times)

Sport(s) played and when:

HighSchool:____

College:____

Current exercise schedule: (fitness time per week and brief description)

Significant injuries past or present: (list what and when)

Data sheet

TEST 1 **date & time:**

Time of 1st dash: **Time of 2nd dash:**

- Shoe description:
- Last time subject ate and what:
- Time spent stretching:
- Notes/variables observed during testing:

TEST 2 **date & time:**

Time of 1st dash: **Time of 2nd dash:**

- Shoe description (same?):
- Last time subject ate and what:
- Time spent stretching:
- Notes/variables observed during testing: