

Investigating the effect of a physical warm-up on reaction time performance

Introduction:

Warming-up before sport has been something that most sports coaches use in order to prepare athletes to perform. The warming-up process is thought to reduce the risk of injury, decrease post-exercise muscle soreness and improve athletic performance (Herbert RD et al 2002 cited in Stewart M et al 2007). In this study they looked a variety of warm-up protocols and their effect on 30 m sprint speed. They showed that warm-up had an impact on sprint performance.

From my point of view, I am interested in seeing whether warming up will have any impact on a person's reactive skills. That is, the speed that the neural impulses move about the body. Does warming the body up with different methods make a real difference to this most basic of tasks – the speed with which you respond to a single stimulus? The purpose of the following investigation is to focus specifically on an athlete's psycho-motor reaction time performance rather than a complete physical performance (30 m sprint test) which Stewart et al (2007) used in their study. The results from this study could potentially provide a strong and valid reason as to why we perform a warm-up beyond that which we already know about and which were highlighted in Herbert et al's 2002 study. The applications of this have the potential to be applied to activities where reaction times are the dominant component of fitness such as team members who are in goal keeping positions.

Aim:

To compare the effect of no warm-up, pre-exercise stretching, a combination of aerobic warm-up and stretching on the performance in a reaction time test (measured in ms \pm 1 ms) in 6 male subjects ranging in age from 16 to 17 years of age.

Dependent variable:

Reaction time measured using an online reaction time test:
<http://www.humanbenchmark.com/tests/reactiontime/index.php>
 Measured in ms \pm 1 ms.

Independent variable:

The type of warm up before testing. The warm up conditions are as follows and the numbers correspond to the student and condition in student allocation table:

1. No warm-up
2. Pre-exercise stretching only
3. Aerobic warm-up and stretching

Control variables:

What?	How to control?	Why does it need controlling?
Sample and distractions	I will have all 6 subjects perform in the same space (classroom) away from external distractions for every condition.	Any distractions will lead to large variations in performance and impact on the ability to compare real data/conditions.
Same warm-up and stretching	Students have a clear protocol to follow for each condition.	If we have variations in warm-up procedure occurring then the ability to compare the effect of the warm-ups will be impacted upon i.e. it impacts directly on the purpose of my study.
Recording of each trial	Subjects will be issued with a pencil and paper to record their individual results from each trial.	The reaction time website will only show you your most recent result along with the average (processed data). So I am wanting to capture the raw data from students – this will allow for further processing e.g.: standard deviation
Practice effect	To negate any change that occurs due to practice I will have them	I am anticipating that subjects will actually warm into the task they

	complete 5 trials that are not recorded before each condition.	are doing – this means that results may get better after a short practice time.
Randomisation of conditions	Randomly have subjects allocated to the 3 different conditions using the website above.	I am applying this to the subjects to eliminate any bias created in the data by having all subjects doing the condition the same way. This means there should be no influence carrying over from one condition to the next.
Time between the warm-up and reaction time test	Have subjects move as quickly as possible to doing the reaction time test from the warm-up condition.	To maximise the effect of the warm-up on performance – if subjects wait too long the warm-up influences will be lost.

Confounding variables (variables we cannot control):

- Laptop used: students to use their normal, personal lap top
- Psychological state on the day. This is acknowledged but there is nothing we can do about how someone is feeling and how their day has gone.

Method:

1. Ask the subjects to indicate their level of fatigue on the 5 point scale below:

1	Feeling fresh and ready to go.
2	Not feeling tired but not as fresh as I could be. Coping well still.
3	Feeling tired – coping but needing more sleep or rest from exercise.
4	Definitely feeling tired – poor sleep and or physically drained.
5	Absolutely shattered – everything is a huge effort and draining. Batteries are flat.

Adapted from: <http://www.intelligent-triathlon-training.com/triathlon-bike-training.html>

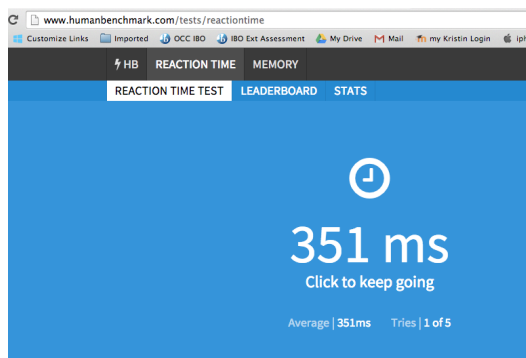
2. Randomly allocate the subjects into the 3 conditions through the use of <http://www.psychicscience.org/random.aspx>

Subject	1	2	3	4	5	6
Experimental condition	1	1	2	3	1	3
	3	2	1	2	2	2
	2	3	3	1	3	1

3. Have subjects get changed into their sports uniforms. They will complete the test in the same uniform for each condition. Each condition will be completed on a separate day.
4. Have experimental condition group 1 (subject 1, 2 and 5) – the no warm-up subjects; log into their computers and use the web browser to access the reaction time website (<http://www.humanbenchmark.com/tests/reactiontime/index.php>).

Have a blank sheet with a pencil next to them for recording of their result.

- Allow them to *practice* with the website for 5 trials to allow them to get accommodated to the programme.



- Have these subjects then complete a further 4 blocks of 5 trials; having 30 seconds to 1 minute breaks between each block. Have subjects record their scores for each of the 5 trials on the blank sheet given to them. These subjects then wait for the next period to complete their next allocated condition.
- Subjects for experimental condition 2 first (subject 3); have them perform a protocol of pre-exercise stretching only (refer below), followed by step 4 and 5 above.
- Subjects for experimental condition 3 first (subject 4, 6); have them perform a protocol of an aerobic warm-up and pre-exercise stretching (refer below), followed by step 4 and 5 above.
- Over the next 2 periods have subjects complete the appropriate condition requirements and record their data as stated in conditions 4 and 5 above.

Condition 2: Pre-exercise stretching procedure. Subjects are to perform each stretch for approx 10-15 seconds before moving to the next muscle group.

Adapted from: <http://www.barriespirit90.com/dynamicstretching.html>

- walking high knees
- high knees pull
- walking lunge
- arm swing, forward and back
- side bend over and back

Condition 3: Aerobic warm-up and pre-exercise stretching procedure. Subjects are to perform 3 x 2 minutes of skipping at a steady rate followed by the stretching already discussed (condition 2).

Observations:

- Often the keyboard wouldn't respond and subject had to click twice.
- At times some subjects anticipated the colour change rather than reacting to it.
- There were differences in sporting uniform and with condition 1 some subjects wore school uniform.
- For condition 3 the skipping rope kept coiling resulting in having to stop skipping to fix this. It was also quite strenuous.

- There were various types of skipping rope - varying in length.
- There were different skipping techniques used (2 footed hop; boxer jog etc).
- Subject 6 had a stimulant (coffee) before condition 2.
- Subjects were differing in alertness for each day of trial – trials were conducted at different times of the day.
- Some values were not used by some individuals due to miss-clicks.

Key to Table 1 and Graph 1:

Table showing the reaction time (± 1 ms) on 6 Year 13 students during 3 different warm-up conditions.																	
Condition																	
1						2						3					
Subject						Subject						Subject					
1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
279	265	231	274	247	235	284	244	221	279	245	271	245	272	227	232	270	228
296	291	233	272	218	283	305	281	243	220	283	263	243	368	226	224	274	250
295	334	251	248	229	234	289	285	245	230	234	255	222	279	210	238	244	255
289	288	242	247	267	269	292	246	255	219	211	239	285	268	226	261	266	228
307	233	233	242	222	292	299	236	218	351	258	265	233	265	225	216	248	282
283	292	245	248	246	290	311	292	235	214	252	254	237	296	226	227	226	229
275	291	221	226	226	269	275	267	238	225	234	255	232	262	227	228	240	290
274	305	248	225	282	244	279	250	237	238	250	264	241	278	223	230	233	247
298	255	231	255	285	269	268	222	225	236	239	260	268	250	236	231	236	272
286	265	232	257	233	283	298	335	231	244	244	254	248	253	266	243	216	304
283	271	256	236	223	291	282	253	241	235	260	333	254	272	226	235	238	270
294	278	244	255	295	269	38	296	244	253	245	243	289	257	237	233	243	262
283	260	264	244	260	246	297	274	222	220	244	303	265	267	240	238	212	288
285	289	271	243	297	255	288	259	234	221	274	287	263	287	231	225	275	269
229	282	285	228	228	251	303	260	248	48	297	243	288	290	235	238	227	269
290	320	267	226	253	226	287	271	241	210	259	222	289	243	231	248	239	272
351	296	337	233	254	239	261	257	236	230	261	255	287	265	234	232	234	245
302	259	219	260	261	261	284	239	237	213	231	284	291	245	240	221	246	255
304	308	268	232	220	231	287	299	231	239	282	222	267	266	224	231	237	264
299	312	239	254	222	259	317	243	242	242	205	237	245	281	238	222	254	234
Mean	263					252					250						
Std Dev	28					40					24						
						256											

Condition 1 = No warm up

Condition 2 = Pre-exercise stretching only

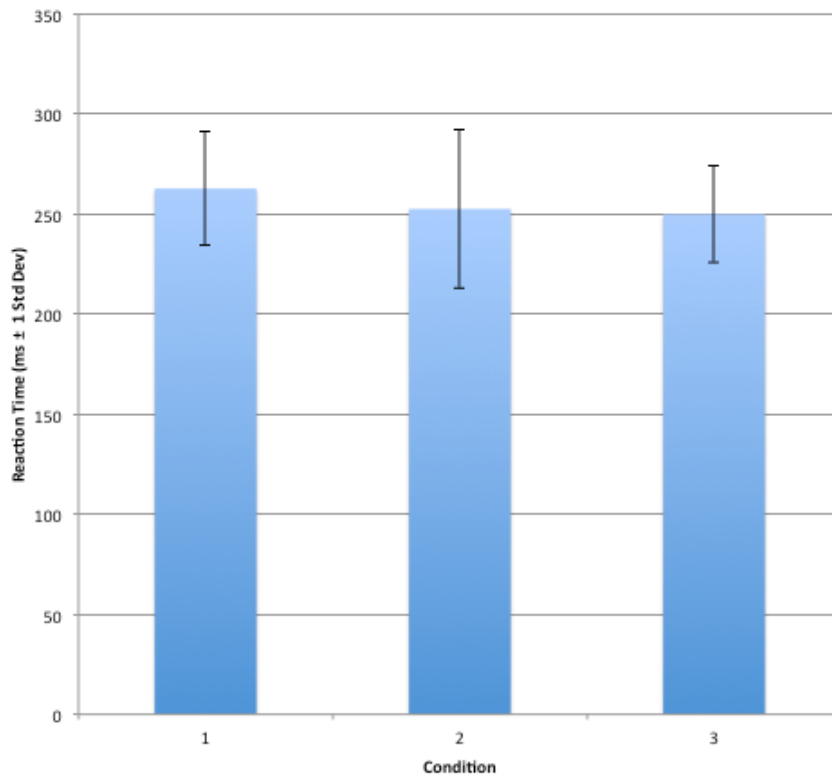
Condition 3 = Aerobic warm-up (Skipping) and pre-exercise stretching

- Data highlighted yellow are considered outliers and were achieved due to anticipation rather than true reaction time. They were eliminated in any further calculations such as t-test and for the graph.
- The data is colour coded to illustrate how the means and standard deviations were obtained ie both mean and standard deviation equations done with Microsoft Excel used all raw data for a particular condition. The mean for condition 2 without the outliers came to 256ms – the standard deviation of this data then drops to 29 ms

Standard deviation example: the highlighted figures were not included for the standard deviation for condition 2.

1						2					
Subject						Subject					
3	4	5	6	1	2	3	4	5	6		
231	274	247	235	284	244	221	279	245	271		
233	272	218	283	305	281	243	220	263	263		
251	248	229	234	269	295	245	230	234	255		
242	247	267	269	292	246	255	219	211	239		
233	242	222	292	299	236	218	351	258	265		
245	248	246	290	311	292	235	214	252	254		
221	226	226	269	275	267	238	225	234	255		
248	225	282	244	279	250	237	238	250	264		
231	255	285	269	268	222	225	236	239	260		
232	257	233	283	298	335	231	244	254	248		
256	238	223	291	282	253	241	235	260	333		
244	255	295	269	38	256	244	253	245	243		
264	244	260	246	297	274	222	220	244	303		
271	243	257	255	288	259	234	221	274	287		
255	228	228	251	303	260	246	48	297	243		
267	226	253	226	287	271	241	210	259	222		
337	233	254	239	261	257	236	230	261	255		
219	260	261	261	284	239	237	213	231	284		
268	232	220	231	287	299	231	239	262	222		
239	254	222	259	317	243	242	242	205	237		
263						252					
28						40					
						256					
						29					

Graph showing the reaction time (ms±1 Std Dev) on 6 Year 13 students during 3 different warm-up conditions.



The data was entered into a t-test calculator (<http://www.graphpad.com/quickcalcs/ttest2/>) with the following results:

QuickCalcs

[1. Select category](#) [2. Choose calculator](#) [3. Enter data](#) [4. View results](#)

Paired t test results

P value and statistical significance:

The two-tailed P value equals 0.0293
By conventional criteria, this difference is considered to be statistically significant.

Confidence interval:

The mean of Condition 1 minus condition 2 equals 6.91
95% confidence interval of this difference: From 0.71 to 13.10

Intermediate values used in calculations:

t = 2.2072
df = 117
standard error of difference = 3.129

Learn more:

GraphPad's web site includes portions of the manual for GraphPad Prism that can help you learn statistics. First, review the meaning of [P values](#) and [confidence intervals](#). Then learn how to interpret results from an [unpaired](#) or [paired](#) t test. These links include GraphPad's popular *analysis checklists*.

Review your data:

Group	Condition 1	condition 2
Mean	262.60	255.99
SD	28.49	28.72
SEM	2.60	2.64
N	120	118

QuickCalcs

[1. Select category](#) [2. Choose calculator](#) [3. Enter data](#) [4. View results](#)

Paired t test results

P value and statistical significance:

The two-tailed P value is less than 0.0001
By conventional criteria, this difference is considered to be extremely statistically significant.

Confidence interval:

The mean of Condition 1 minus condition 3 equals 12.80
95% confidence interval of this difference: From 7.43 to 18.17

Intermediate values used in calculations:

t = 4.7241
df = 119
standard error of difference = 2.710

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Review your data:

Group	Condition 1	condition 3
Mean	262.60	249.80
SD	28.49	24.06
SEM	2.60	2.20
N	120	120

QuickCalcs

1. [Select category](#) 2. [Choose calculator](#) 3. [Enter data](#) 4. [View results](#)

Paired *t* test results

P value and statistical significance:

The two-tailed P value equals 0.0347
By conventional criteria, this difference is considered to be statistically significant.

Confidence interval:

The mean of condition 2 minus condition 3 equals 6.18
95% confidence interval of this difference: From 0.45 to 11.90

Intermediate values used in calculations:

$t = 2.1368$
 $df = 117$
standard error of difference = 2.891

Learn more:

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Review your data:

Group	condition 2	condition 3
Mean	255.99	249.80
SD	28.72	24.06
SEM	2.64	2.20
N	118	120

Conclusion:

This experiment showed that reaction time was shorter with a full warm up (condition 3), followed by stretching (condition 2) and finally the longest time resulted in no warm up of any sort (condition 1). With the analysis of the results it shows that the mean value of condition 1 (no warm up) was 263 ms; the mean value of condition 2 (only stretching) was 252 ms; and finally the mean value of condition 3 (full aerobic warm up with stretching) was 250 ms. This indicates that as the preparation/warm-up is increased, the reaction time is faster. The data was then put into a paired t-test calculator to see whether these differences were significant and in all cases they have come out positive. That is, the reaction times gained from no warm-up are significantly slower than those obtained when the subjects completed either stretching or aerobic warm-up and stretching. Also the reaction times from doing an aerobic warm-up and stretching was significantly faster than doing just stretching.

Reaction time can be described as: "the interval time between the presentation of a stimulus and the initiation of the muscular response to that stimulus"¹ This means when we receive a stimulus (such as the colour change from the human bench mark test) the reaction time is from this change of stimulus to the 'muscular response' (the click of the mouse in this case). It is stated that warm-up has a positive effect on reaction time – as shown by this experiment. Warm up ensures "the sense organs and nervous system are ready to transmit information and the muscles to act upon it"¹ This means that with a warm up, we are more alert to possible stimuli and therefore with a greater warm up, reaction time will be faster.

1 <http://www.brianmac.co.uk/reaction.htm>

With reference to the observations, the difference in warm up was evident – condition 3 was quite strenuous whilst condition 2 was considerably lighter. This showed in the results as condition 3 significantly outperformed condition 2.

The trends found by this investigation coincide with those of others. An example being the study 'Effect of Acute Static Stretching on Force, Balance, Reaction Time, and Movement Time' by David Behm, Andrew Bambury, Farrell Cahill, and Kevin Power. It indicates that there are significant differences on reaction time just with acute static stretching – a 5.8% decrease in reaction time. This supports this investigation and study, increasing the validity and reliability.

The standard deviation of condition 2 is relatively large (± 40 ms) compared with 28 ms and 24 ms for Conditions 1 and 3 respectively. When you look at the raw data it is clear that there were some outliers in Condition 2 which have contributed to this situation. This will be discussed further in the evaluation.

Overall as shown by this investigation, textbooks and other related studies; we can conclude that the extensiveness of the warm up has an effect on reaction time – as the preparation (warm up) increases, reaction time decreases.

Evaluation & Improvements:

As a whole the results were fairly reliable however this is compromised particularly by condition 2 as the standard deviation is 40 ms (a considerable amount larger than the other two conditions). This is due mainly to outliers such as subject 4's trial 15 where they got a reaction time of 48 ms. This is humanly impossible, thus it was anticipation by the individual affecting the results. Also subject 1 on trial 12 got a reaction time of 38 ms – another anticipation. On the other hand there were a range of unreliable results (generally over 300 ms) where some subjects stated that they clicked and the computer didn't initially respond, this too affects the reliability and validity of the results. However as there were essentially 120 sets of data from 6 different subjects, this reliability and validity wasn't compromised drastically.

There were a range of factors/limitations that affected the results:

- Outlier results due to anticipation or miss-clicks. This meant if the individual anticipated the colour change (stimulus) the mean reaction time for that condition would decrease (reacted faster). On the other hand if the individual had to double click due to a miss-click this would increase (reacted slower) the mean reaction time for that condition.
- Diet before testing- one subject had coffee before reaction test (stimulant). This meant that this individual's reaction time for condition 2 could have improved as coffee has been said to improve reaction time (depending on when it was consumed). This means there is a chance that this factor has decreased the mean reaction time for condition 2.
- Time of day altered when tests were being conducted which affected alertness for the test. If it was later in the day and individuals are more tired, and less alert, this would increase their reaction time and therefore the mean reaction time and vice versa.
- Different laptops affected the reaction time because the mouse pads differed with the different

laptops. Mouse pads which were more rigid and more difficult to click would compromise reaction time for that subject and therefore increase their reaction time as well as the mean reaction times across all three conditions.

- Difficulty of condition 3 as the skipping for that amount of time was quite challenging and therefore fatigue played a large factor. As it was quite rigorous, it caused some subjects to fatigue, as they were fatigued this may mean that their reaction time would increase and therefore the mean reaction time for condition 3 would increase due to the factor of fatigue.

There was a measurement error of ± 1 ms allocated for the use of the human benchmark reaction time test. The accuracy is due to the speed of response from the laptop to a person pushing the button in the test.

The range of independent variables and replicates were appropriate. There were 20 trials for each individual, which assisted in ensuring that any outliers would not significantly influence the processed data. The range of independent variables was good however they consisted of:

1. No warm-up
2. Pre-exercise stretching only
3. Aerobic warm-up and stretching

I believe what is missing is one variable between conditions 2 and 3. An example of this could be just a light aerobic warm up without stretching. If this was incorporated we could also be able to deduce how much of a factor fatigue was on condition 3.

The control variable of the same computer used across all six subjects, diet, and distractions were quite difficult to control. Computers were difficult to control because subjects were expected to conduct one test at home due to a lack of time. Diet was difficult to control as ultimately it was up to the individual/subject. And distractions also proved to be difficult to control as there were other subjects in the same room (also coming in and out from warm-ups) doing the same tests.

Limitation	Improvement	Variable(s)	Alternative method(s) modifications to method
Outlier results due to anticipation or miss-clicks	Ensure that all subjects wait for the reaction and don't encourage anticipation. Regarding miss-clicks, they should not be considered as they are not fair values.	Reaction/click of the mouse	Add in method to instantly remove any obvious outliers due to the factors of anticipation or miss-clicks. An alternative test could also be used such as the ruler drop test to eliminate this miss-click factor, however the anticipation factor would still be present.
Diet before testing – one subject had coffee before reaction test (stimulant)	Primarily ensure subjects do not consume anything that can alter alertness or state of mind prior to testing. This includes coffee or energy drinks.	Diet	Mention in method what not to have prior to testing.
Time of day altered when tests were being conducted which affected alertness for the test	A standard period of time should be kept throughout all tests. Ideally the same time for each condition, or alternatively a given time period – preferably when subjects are most alert.	Time of day	Add in method that testing time must be at a certain time, eg 8.30am to 10.30am.

Different laptops affected the reaction time because the mouse pads differed with the different laptops	Ensure all subjects use one laptop. This means that the testing would be more time consuming and would have to be conducted at one standard location. Alternatively, the same brand of laptop could be used (eg the school laptops).	Laptops	An alternative test could be used such as the ruler drop test to eliminate this factor of different laptops.
Difficulty of condition 3 as the skipping for that amount of time was quite challenging and therefore fatigue played a large factor	This could be improved by lowering the time of skipping to a reasonable time where subjects don't fatigue. Also there would have to be one set skipping technique that all subjects can perform.	Condition 3	Alter method by lowering the skipping time to an agreed amount by subjects.

References:

Matthew Stewart, Roger Adams, Albert Alonso, Blake Van Koesveld, Scott Campbell. Warm-up or stretch as preparation for sprint performance? *Journal of Science and Medicine in Sport* (2007)10,403—410