Achievement Standard 91265 (Mathematics and Statistics 2.10)

Conduct an experiment to investigate a situation using statistical methods

Practice assessment

Solution

Answers may vary – an example follows.

Problem: Does restricting the movement of the arms while running (so that the arms cannot move independently) cause a change in running speed?

Based on my own experience, I predict that not being able to move your arms independently will result in slower runner speeds.

Research has shown that arm swing help determine your stride when running – so being able to swing your arms freely should allow students to be able to run faster, longer and with less perceived effort. (Source: Professional Runners Association).

I have selected arm movement as an indicator of technique and will investigate how a change in arm motion affects running speed.

Plan: A group of 60 male Year 12 students will be randomly placed in one of two groups (Group 1 and Group 2). I will randomly assign the number 1 or 2 to a student (using 2Ran# + 1) and when one group has 30 students, the remaining students will go into the other group.

A 100-metre course will be marked out for the students to do a timed run. I have chosen a 100-metre course as most students should be able to run this distance comfortably – longer distances would mean that fitness would play a greater role, with some students perhaps choosing to walk. 100 metres is a sprint distance and running technique may have a more noticeable impact on times with the shorter distance.

To ensure consistent timing, a controller will be place at the beginning of the 100-metre course. This controller will lower a flag to start the runners; two controllers will be at the end of the course timing the run with stopwatches from when the flag drops to when the runner crosses the finish line. The controllers will compare their times, and if they are not the same, then the median of the two times obtained will be recorded.

The first group of 30 students will run the 100-metre course, using their usual running style, and be timed (in seconds). The second group of 30 students will run the same 100-metre course but while holding a rugby ball with both hands on the ball. This is designed to restrict their arm motion.

Students will run the 100-metre course one at a time to enable accurate timing.

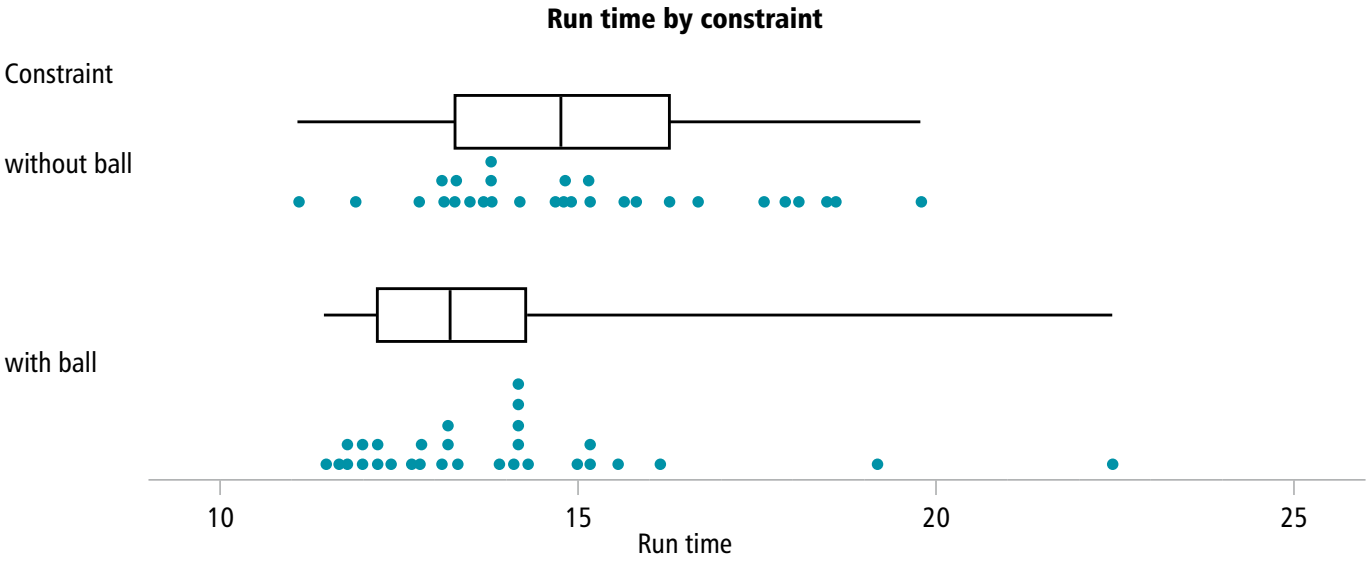
I will ensure students all run in the same direction on the course to minimise the impact of any wind, which may affect times. Having thirty students in each group, and each student randomly assigned to a group, should help minimise the effect of individual differences.

Data: The following is the recorded data.

Time (seconds) for 100 m run	
Without ball	With ball
14.7	12.7
14.2	14.3
13.7	13.9
18.1	22.5
18.6	14.2
11.1	12.4
13.8	15.2
13.2	12.8
13.5	12.2
16.7	13.3
15.2	12.8
14.8	13.2
13.8	14.2
13.1	15.2
14.9	12
13.8	11.7
15.8	12.2
15.2	13.1
14.8	12
13.3	11.8
11.9	11.8
17.9	13.2
17.6	15.6
19.8	11.5
18.5	14.2
13.3	16.2
15.7	19.2
16.3	15
12.8	14.1
13.1	14.2

Analysis:

Summary of statistics for 100-metre run times by constraint (with/without ball) in seconds								
	Min	LQ	Med	UQ	Max	Mean	Std dev (s)	Sample size
Without ball	11.1	13.3	14.75	16.3	19.8	14.97	2.148	30
With ball	11.5	12.2	13.25	14.3	22.5	13.89	2.318	30



The median run time while holding a ball was 13.25 seconds, compared with 14.75 seconds without a ball, a difference of 1.5 seconds. The lower quartile of run times without a ball is approximately equal to the median run time with a ball. This means that at least 75% of run times without a ball were slower than half of run times with a ball. The median run time with a ball is outside the box for the run times without a ball, so the shift in the medians indicates that run times with a ball are significantly faster.

The mean run time in each case was slightly higher than the median run time (mean of 13.89 seconds with the ball and and a mean of 14.97 seconds without the ball). These higher mean run times are a result of the skew to the right in each group, particularly for the group running with the ball which had an outlier of 22.5 seconds, which has a long right whisker as a result.

Although run times with a ball had the lower median time, the same group had the slowest runner (22.5 seconds). This extreme value may need to be checked to ensure the conditions of the experiment were properly met.

The interquartile range for run times with a ball is 2.1 seconds, which is 0.9 seconds less than the interquartile range for run times without a ball of 3 seconds. So the middle 50% of run times with a ball tend to be more consistent than the middle 50% of run times without a ball.

Run times with a ball show a slightly greater spread of values overall (slightly higher standard deviation of 2.318 seconds with a ball compared with a standard deviation of 2.148 seconds without a ball).

The distribution of run times without a ball is somewhat uniform, while the distribution of run times with a ball appears to have more of a normal distribution, as values are more clustered around the centre with a mode of 14.2 seconds. The middle 50% of neither data set appears to be skewed, with both having medians approximately central to the box showing the middle 50% of run times.

Run times without a ball have resulted in quite a symmetrical box plot overall, unlike run times with a ball. Although the central 50% of run times with a ball (the box) is quite symmetrical, the distribution of run times with a ball is positively skewed because of the long right whisker representing the slowest 25% of times recorded when running with the ball.

Conclusion

Based on the box-and-whisker plots, and on the difference in mean run times, it appears that running while holding a ball caused the students to be able to run faster. The random sample size of 60, randomly assigned to two groups of 30, should make these results reliable, but a different sample would give different results due to sampling variability.

This result is not what I predicted, but I think this may be to do with how the arm movement was restricted (by holding a ball). People are used to running with a ball when playing sport, etc., but may not have run so fast if they had to run with their arm movements restricted in a less familiar way, e.g. by tying their hands behind their backs.

Researchers found that having attributes like a faster stride, less torso movement, and a freer movement of your arms and shoulders led to better running economy. Having better running economy can help you run at a faster pace with the same amount of effort. (Source: *Mens Health News* 2012) It may be that running while holding a ball has resulted in less torso movement, with students concentrating more on their running action. While holding the ball students were still able to move their arms in a restricted manner, but this may have been compensated for by the more upright and controlled motion adopted when holding the ball.

There may be other variables affecting students' running times. As students were running one at a time and those running with the ball went last, it may have been that runners with a ball had a chance to observe other runners and devise strategies for more effective running. It may have been better to have the students run in a random order, or out of sight of one another.

Also, a number of the students involved in the experiment were rugby players and this may have made them more confident in running while holding a ball. It may be of interest to investigate this situation further, comparing run times for students who regularly play a ball sport to run times of students who do not regularly play a ball sport.

These results apply only to Year 12 boys over a 100-metre course, and I may have seen quite different results if girls had been involved in the experiment, or different age groups, or a different length of running course.