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(54) **Title:** UNI-LATERAL SLED

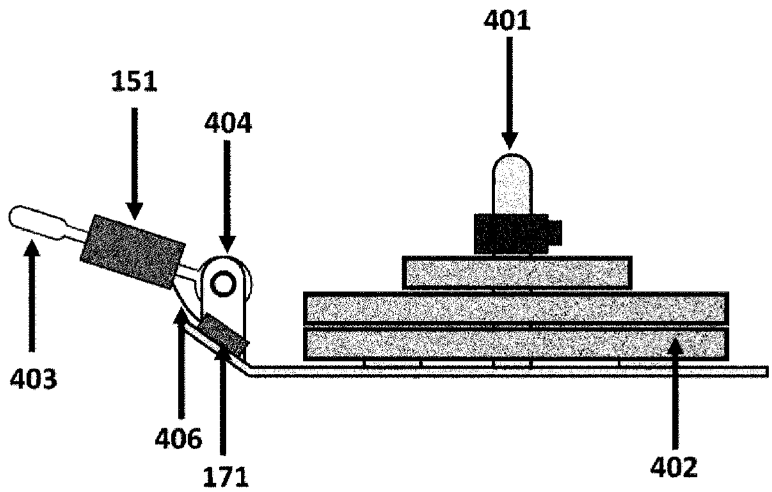

Figure 3

(57) **Abstract:** A measurement system for evaluating athletes using a weighted resistance towing sled to which an athlete is connected using a harness and tether, is described, the measurement device comprising: a force sensing device located in the connection between the athlete and the sled, the force sensing device having a load cell, the force sensing device measuring the force exerted on the sled by the athlete; a second sensing device, the second sensing device having at least one accelerometer; and a communication device for communicating data from the sensing devices, wherein the second sensing device provides data for the calculation of at least linear velocity, linear acceleration and linear distance travelled.

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UNI-LATERAL SLED

FIELD

This invention relates to a uni-lateral sled and force measurement device, apparatus and system.

BACKGROUND

Unbalanced unilateral (single leg) horizontal force is linked to various type of injuries include hamstring, groin injury, hip flexor, knee ligament and lower back. Understanding unilateral horizontal force is also useful for training performance and monitoring. Injuries above commonly occur in athletes of many popular sport events in which high speed sprinting is frequently performed, including track and field events, football, and rugby. Injuries such as hip injury has a very high recurrence rate. In the English professional soccer/football leagues, hamstring strain injury reoccurred between 12% to 48% of the players. In addition, the persistence of the recurrence was reported to continue for many weeks after returning to play with cumulative recurrence risk of 31%. In many cases, hamstring injuries have led to considerable time lost from training and competition, which result in financial loss and diminished athletic performance.

Epidemiological data obtained from football, soccer, and rugby, across several years indicates that hamstring injuries have not declined in recent decades. The average cost of a single acute hamstring injury in the Australian Football League based on player salary and time missed has been published and was greater than $45,000 NZD in 2012. Estimated costs for soccer players in the English Premier League are over 10 times higher (i.e. >$450,000 NZD per hamstring injury). Despite the serious implications of hamstring injury, current methods such as instrumented treadmills, shoe sensors, isokinetic dynamometer and force plates are inadequate owing to high cost, limited portability, and the requirement for experienced operators to use the device.

An example of an instrumented treadmill is the Woodway which is between $30,000 to $50,000 NZD and it does not accommodate change in angle and it is often considered biomechanically different to over-ground sprinting. The attraction of the proposed device is not only injury prevention but also training performance and monitoring. The current solutions for unilateral force, in the context of training performance and monitoring, suffers from the same limitations as above – high cost, limited portability, and require specialised knowledge to operate. In summary, there is a market need for a cheaper and more accurate method of assessing injury risks, performance monitoring and improvement.

Devices used for assessing unilateral force production include instrumented treadmills, pressure sensors in shoes, accelerometers and multiple in-ground force plates. Instrumented treadmill's advantages include the ability to assess force production for several steps and accurate and reliable data. Instrumented treadmills, however, are costly, and require highly specialised knowledge for data analysis. Pressure sensors are easy to use, however have not proved to be useful for this purpose. Accelerometers are easy to use but have not been proven to be useful for unilateral force assessment and require time to process and analyse the data. Only a few facilities in the world have enough in-ground force plates in a row to make assessment possible but the cost of a sufficient number of in-ground force plates is in the magnitude of millions.

The isometric mid-thigh pull is widely used as a total body strength assessment. The traditional method has been to use expensive force plates in a lab based environment. The force plates are usually immovable (fixed in floors) or are very large and heavy to move around.

The present invention may provide an improved uni-lateral sled and force measurement device or at least provide the public or industry with a useful choice.

SUMMARY

According to one example embodiment there is provided a measurement system for evaluating athletes using a weighted resistance towing sled to which an athlete is connected using a harness and tether, the measurement device comprising:

a force sensing device located in the connection between the athlete and the sled, the force sensing device having a load cell, the force sensing device measuring the force exerted on the sled by the athlete;

a second sensing device, the second sensing device having at least one accelerometer; and

a communication device for communicating data from the sensing devices,

wherein the second sensing device provides data for the calculation of at least linear velocity, linear acceleration and linear distance travelled.

Preferably a second tether connects between the harness and the weighted resistance towing sled, the measurement system including a second force sensing device and wherein the second force sensing device is located between the harness and the weighted resistance towing sled for each tether.

Preferably the force sensing device is directly attached to the weighted resistance towing sled.

Preferably the force sensing device is directly attached to the harness.

Preferably the force sensing device is inline in the tether.

Preferably the load cell is a 1D load cell.

Alternatively, the load cell is a 2D load cell.

Preferably the force sensing device further has at least one accelerometer.

Preferably the force sensing device further has at least one gyroscope.

Preferably the force sensing device further has at least one magnotometer.

Preferably the second sensing device further has at least one gyroscope.

Preferably the second sensing device further has at least one magnotometer.

Preferably the second sensing device further provides data for the calculation of the force for left and right steps and the ratio between left and right steps.

Preferably the communication device is a wireless communication device.

According to a further example embodiment there is provided a system for evaluating athletes comprising:

the measurement system described above; and

software executable on an electronic computing device for receiving the data and computing at least linear velocity, linear acceleration and linear distance travelled.

According to a still further example embodiment there is provided a measurement system for evaluating athletes comprising:

the measurement system of any one of claims 1 to 14; and

software executable on an electronic computing device for receiving the data and computing at least linear velocity, linear acceleration, linear distance travelled, the force for left and right steps and the ratio between left and right steps.

According to a yet further example embodiment there is provided a kit including:

the measurement system of any one of claims 1 to 14; and

one or more of the group consisting of a weighted resistance towing sled, a harness and a tether.

According to a further example embodiment there is provided an apparatus for evaluating athletes comprising:

a weighted resistance towing sled;

a force sensing device attached to the weighted resistance towing sled, the force sensing device further having an attachment to which a first tether can be attached, the tether connecting the athlete and the sled, the force sensing device having a load cell to measure the force exerted on the sled by the athlete;

a second sensing device mounted on the sled, the second sensing device having at least one accelerometer; and

a communication device for communicating data from the sensing devices,

wherein the second sensing device provides data for the calculation of at least linear velocity, linear acceleration and linear distance travelled.

Preferably the weighted resistance towing sled, includes a rotating hinge joint and wherein the force sensing device is attached to the weighted resistance towing sled via the rotating hinge joint.

Preferably a second force sensing device weighted resistance towing sled the second force sensing device further having an attachment to which a second tether can be attached, the first and second tethers connecting the athlete and the sled.

Preferably the load cell is a 1D load cell.

Alternatively the load cell is a 2D load cell.

Preferably the force sensing device further has at least one accelerometer.

Preferably the force sensing device further has at least one gyroscope.

Preferably the force sensing device further has at least one magnotometer.

Preferably the second sensing device further has at least one gyroscope.

Preferably the second sensing device further has at least one magnotometer.

Preferably the second force sensing device further provides data for the calculation of the force for left and right steps and the ratio between left and right steps.

Preferably the communication device is a wireless communication device.

According to a still further example embodiment there is provided a system for evaluating athletes comprising:

the apparatus describe above; and

software executable on an electronic computing device for receiving the data and computing at least linear velocity, linear acceleration and linear distance travelled.

According to another example embodiment there is provided a system for evaluating athletes comprising:

the apparatus described above; and

software executable on an electronic computing device for receiving the data and computing at least linear velocity, linear acceleration, linear distance travelled, the force for left and right steps and the ratio between left and right steps.

According to yet another example embodiment there is provided a method of calculating at least linear velocity, linear acceleration, linear distance travelled of a weighted resistance towing sled having a force sensing device including at least one accelerometer:

receiving the accelerometer data;

filtering the data to remove noise;

identifying the start of movement; and

calculating linear velocity, linear acceleration, and linear distance travelled from the accelerometer data.

Preferably the method further includes calculating the force for left and right steps and the ratio between left and right steps of a weighted resistance towing sled having a force sensing device including a strain gauge and gyroscope, the method including the steps of:

receiving the strain gauge data;

filtering the data to remove noise;

calculating the force;

receiving the gyroscope data;

filtering the data to remove noise;

calculating the angle of pull;

calculating from the force and the angle of pull the horizontal and vertical forces;

detecting the steps; and

calculating the force for left and right steps and the ratio between left and right steps.

It is acknowledged that the terms “comprise”, “comprises” and “comprising” may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, these terms are intended to have an inclusive meaning – i.e., they will be taken to mean an inclusion of the listed components which the use directly references, and possibly also of other non-specified components or elements.

Reference to any document in this specification does not constitute an admission that it is prior art, validly combinable with other documents or that it forms part of the common general knowledge.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings which are incorporated in and constitute part of the specification, illustrate embodiments of the invention and, together with the general description of the invention given above, and the detailed description of embodiments given below, serve to explain the principles of the invention, in which:

Figure 1 is a schematic diagram of a force sensor unit;

Figure 2 is a plan view of an embodiment of a sled;

Figure 3 is a side view of the of an embodiment of the sled;

Figure 4 is an image of an alternative embodiment of the sled;

Figure 5 is a view of a harness used for pulling a sled;

Figure 6 is a flow diagram of the data processing of the force sensing system data;

Figure 7 is a flow diagram of the data processing of the additional module data; and

Figure 8 is an alternative flow diagram of the data processing of the force sensing system data.

DETAILED DESCRIPTION

Referring to Figure 1 a measurement system 170 includes an inertial measurement unit / IMU 161. The force sensing system/platform is comprised of a force sensing device 151 that is wirelessly interfaced 156, 157 to a receiver 158. The receiver 158 may be a specialised computing device running custom firmware 159 or may be an application 159 suitable for running on a smartphone or other electronic computing device 160.

The measurement system 170 may be mounted or attached to a sled via a swivel joint restrained in one plane, alternatively a swivel joint restrained in two planes or a swivel joint not restrained in any plane. The measurement system may use multiple load-cells. In an example one on left and right side of sled with an interconnecting bridle.

In a further alternative the measurement system 170 may be mounted or attached to a belt or harness worn by a person via a swivel joint restrained in one plane, alternatively a swivel joint restrained in two planes or a swivel joint not restrained in any plane. In a further example one on left and right side the harness with an interconnecting bridle.

In a further alternative the measurement system could be located inline in a non-elastic tether between a sled and athlete.

The force sensing device 151 is typically enclosed in a case, and includes a circuit board, a power source such as a battery 154, a microcontroller, including a processor 152 and memory in communication with the processor. The power source, processor and memory may be located in a separate case. The memory storing software/firmware 153 executable by the processor, the force sensing device 151 further includes a communication module in one embodiment a wireless communication device/module 156, a one direction (1D) load cell 155 and an inertial measurement unit 161. The inertia measurement unit 161 includes a magnetometer, a gyroscope and at least one accelerometer.

The measurement system can communicate with further expansion modules including second sensing device 171 such as an additional inertial measurement unit 174 also illustrated in Figure 2. The expansion module 171 includes an inertia measurement unit 174, a microcontroller 172, including a processor 175 and memory in communication with the processor. The expansion module 171 is controlled by firmware 173 and is typically wired to the force sensing device 151. Multiple expansion modules may be used. The inertia measurement unit 174 includes a magnetometer, a gyroscope and at least one accelerometer.

Referring to Figures 2 and 3 there is depicted a wireless force sensing device 151 mounted on a weighted resistance towing sled 401 with an inertial measurement unit expansion board 171. The resistance towing sled 401 may be fitted with a plurality of weights 402. The purpose of this system is to measure the single leg vertical and horizontal components of force produced by a user whilst a user is performing a resisted sprint using a weighted sled. The user will wear a harness, which will be attached to a non-elastic tether. The tether will be attached 403 to wireless force sensing device 151 via an attachment member by for example an eyebolt, which will be mounted on the sled 401 via a rotating hinge joint 404. The wireless force sensing device 151 will be wired (preferably discreetly) 406 to an addition inertial measurement unit expansion module 171. Optionally the wireless force sensing device 151 and the expansion module 171 will be covered by a waterproof shell. Optionally the wireless force sensing device 151 will be wirelessly connected to an addition inertial measurement unit expansion module 171.

The inertial measurement unit on the wireless force sensing device 171 will output the angle of pull by measuring the angle of the device relative to the ground. The angle and force will be used to calculate the horizontal and vertical force vectors experienced on the sled 401 during a resisted sprint. The inertial measurement unit on the expansion board 171 will measure the linear over-ground acceleration of the sled.

A software program wirelessly acquires the data from the device 170 and displays the data on a PC or smartphone (or another device as discussed above) remotely. The wireless force sensing system in combination with the software will allow for assessment of unilateral (i.e. single-leg) horizontal force production during over-ground resisted sprinting. Variables available will include single leg horizontal force, power, velocity and acceleration. These variables can be measured during maximal sprint exercise, submaximal running, or other movements (e.g. striding, fireman's pull).

The sled is a tool for the training, testing and monitoring of maximal sprinting performance during all sprint phases. Including, but not limited to: initial acceleration (first few steps), acceleration, maximum velocity and deceleration. The outputs from the device will enable the user to make empirical judgements surrounding the current performance level of the athlete, potential risk of sports injury, and directly implement training protocols using the device itself.

Referring to Figure 4 an alternative embodiment is illustrated a user 100 will wear a harness 101, which will be attached to two non-elastic tethers 102. Each tether 102 will be attached to a force sensing device 151 via an attachment member by for example an eyebolt, which will be mounted on the sled 401.

Referring to Figure 5 an alternative embodiment is illustrated a user 100 will wear a harness 101, which will be attached to a force sensing device 151 that may or may not include an IMU. The force sensing device 151 will in turn be attached to a tether 102. An IMU 106 may be used to calculates the linear distance, velocity and acceleration variables can be located on the harness 100 and house the battery and the transmitter that transmits the data to a receiver. Multiple force sensing devices 151 may be used and two or more tethers may be used to connect to the sled.

Referring to Figures 6 and 7 the software then processes the data collected from the sled sensors including strain gauge 610, magnetometers 620, 720, gyroscopes 630, 730 and accelerometers 640, 740 using at least the following steps:

Referring to Figure 6 the software receives the strain gauge data 610, filters 611 the data to remove noise and produce a force measurement 612.

From the magnetometers 620, gyroscope 630 and accelerometers 640 the system receives data and applies a filter 621, in one embodiment a Kalman filter, the software then calculates the angle of pull 622. Based 613 on the force 612 and the angle of pull 622 the system calculates horizontal force 614 and vertical force 615.

Using a peak detection algorithm each step is detected as left or right 616 and the maximum force at each step is calculated and the system displays the average force for left 617 and right 619 steps and the ratio 618 between left and right.

From the additional module 171 the system calculates linear velocity 714, linear acceleration 715 and the distance covered 716. To do so the system receives from the IMU 174 data from the magnetometers 720, gyroscope 730 and accelerometers 740. The system then filters the data 711, fuses/integrates the data 712. From the fused data, the system detects the start of the sprint 713 by looking for the first step in the force data and from that information converts the IMU data into linear velocity 714, linear acceleration 715 and linear distance travelled 716.

If the force sensing device 151 data was received from a force sensing device 151 attached to a harness or from a force sensing device inline with the tether, then additional processing to remove the noise caused by the human moving in the Z direction (vertical) would be used. When the force sensing devices are located on the sled, since the sled does not move in the Z direction no filtering is necessary in the Z-plane.

Alternatively, the 1D load cells may be replaced with 2D (two direction) load cells. When using 2D load cells it would not be necessary to calculate the angle of the force generated using the IMU as the 2D load cells can provide sufficient information without the IMU. This if a 2D load cell is used the force sensing device would not need an IMU.

When using 2D load cells referring to Figure 8 the software receives the load cell data 810, filters 811 the data to remove noise and produce a force measurement 812.

From the 2D load cells 810 the system receives data and applies a filter 811, in one embodiment a Kalman filter, the software then calculates horizontal force 814 and vertical force 815.

Using a peak detection algorithm each step is detected as left or right 916 and the maximum force at each step is calculated and the system displays the average force for left 817 and right 819 steps and the ratio 818 between left and right.

From the additional module 171 the system calculates linear velocity 714, linear acceleration 715 and the distance covered 716 in the manner described above.

When using two tethers and two force sensing devices 151 the measurements would be summed to get a global pulling force. Using two IMUs (one in each force sensing device 151) would give two angles of pull and the angles summed using trigonometry. If the standard 1D load cell was replaced by a 2D load cell then no IMU would be necessary within the force sensing device 151.

Distance may additionally or alternatively be calculated using distance sensing equipment including timing gates; UWB positioning technology; video; radar and lidar. The data obtained for these measurements can be used to enhance or replace the distance data from the IMU.

The system can provide the following measurements

1. Sprinting force and unilateral (i.e. single-leg) horizontal force horizontal force measured by the load cell.
2. Angle of pull measured by IMU.
3. Linear acceleration and velocity of sled measured by IMU expansion board.
4. Integration optimal training load parameters.

Further the system could be integrated on the basis of time with other technologies (e.g. video or radar) and may in an alternative embodiment provide other measurements including impulse and rate of force development.

The measurement system 170 may be provided separately from the sled or the sled and measurement system 170 provided together.

When provided separately for use with a user's existing sled the system would include:

- one or more force measuring devices 151 including either a 2D load cell or a 1D load cell with an IMU and a transmitter
- an additional IMU module 171 to be placed somewhere on the sled.

When used with a user's existing sledge a one-time calibration routine would be needed.

In a further alternative when the measurement system 170 is mounted or located in the harness, the harness incorporating the measurement system could be sold separately or with a sled. Likewise when the measurement system is located inline in the tether, the tether incorporating the measurement system 170 could be sold separately from the harness and the sled.

While the present invention has been illustrated by the description of the embodiments thereof, and while the embodiments have been described in detail, it is not the intention of the Applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details, representative apparatus and method, and illustrative examples shown and described. Accordingly, departures may be made from such details without departure from the spirit or scope of the Applicant's general inventive concept.

CLAIMS:

1. A measurement system for evaluating athletes using a weighted resistance towing sled to which an athlete is connected using a harness and tether, the measurement device comprising:

    a force sensing device located in the connection between the athlete and the sled, the force sensing device having a load cell, the force sensing device measuring the force exerted on the sled by the athlete;

    a second sensing device, the second sensing device having at least one accelerometer; and

    a communication device for communicating data from the sensing devices,

    wherein the second sensing device provides data for the calculation of at least linear velocity, linear acceleration and linear distance travelled.

2. The measurement system of claim 1 wherein a second tether connects between the harness and the weighted resistance towing sled, the measurement system including a second force sensing device and wherein the second force sensing device is located between the harness and the weighted resistance towing sled for each tether.

3. The measurement system of claim 1 or claim 2 wherein the force sensing device is directly attached to the weighted resistance towing sled.

4. The measurement system of claim 1 or claim 2 wherein the force sensing device is directly attached to the harness.

5. The measurement system of claim 1 or claim 2 wherein the force sensing device is inline in the tether.

6. The measurement system of any one of claims 1 to 5 wherein the load cell is a 1D load cell.

7. The measurement system of any one of claims 1 to 5 wherein the load cell is a 2D load cell.

8. The measurement system of any one of claims 1 to 7 wherein the force sensing device further has at least one accelerometer.

9. The measurement system of one of claims 1 to 8 wherein the force sensing device further has at least one gyroscope.

10. The measurement system of any one of claims 1 to 9 wherein the force sensing device further has at least one magnotometer.

11. The measurement system of any one of claims 1 to 10 wherein the second sensing device further has at least one gyroscope.

12. The measurement system of any one of claims 1 to 11 wherein the second sensing device further has at least one magnotometer.

13. The measurement system of any one of claims 1 to 12 wherein the second sensing device further provides data for the calculation of the force for left and right steps and the ratio between left and right steps.

14. The measurement system of any one of claims 1 to 13 wherein the communication device is a wireless communication device.

15. A system for evaluating athletes comprising:

the measurement system of any one of claims 1 to 14; and

software executable on an electronic computing device for receiving the data and computing at least linear velocity, linear acceleration and linear distance travelled.

16. A measurement system for evaluating athletes comprising:

the measurement system of any one of claims 1 to 14; and

software executable on an electronic computing device for receiving the data and computing at least linear velocity, linear acceleration, linear distance travelled, the force for left and right steps and the ratio between left and right steps.

17. A kit including:

the measurement system of any one of claims 1 to 14; and

one or more of the group consisting of a weighted resistance towing sled, a harness and a tether.

18. An apparatus for evaluating athletes comprising:

a weighted resistance towing sled;

a force sensing device attached to the weighted resistance towing sled, the force sensing device further having an attachment to which a first tether can be attached, the tether connecting the athlete and the sled, the force sensing device having a load cell to measure the force exerted on the sled by the athlete;

a second sensing device mounted on the sled, the second sensing device having at least one accelerometer; and

a communication device for communicating data from the sensing devices,

wherein the second sensing device provides data for the calculation of at least linear velocity, linear acceleration and linear distance travelled.

19. The apparatus of claim 18 wherein the weighted resistance towing sled, includes a rotating hinge joint and wherein the force sensing device is attached to the weighted resistance towing sled via the rotating hinge joint.

20. The apparatus of claim 18 or claim 19 including a second force sensing device weighted resistance towing sled the second force sensing device further having an attachment to which a second tether can be attached, the first and second tethers connecting the athlete and the sled.

21. The apparatus of any one of claims 18 to 20 wherein the load cell is a 1D load cell.

22. The apparatus of any one of claims 18 to 20 wherein the load cell is a 2D load cell.

23. The apparatus of any one of claims 18 to 22 wherein the force sensing device further has at least one accelerometer.

24. The apparatus of any one of claims 18 to 23 wherein the force sensing device further has at least one gyroscope.

25. The apparatus of any one of claims 18 to 24 wherein the force sensing device further has at least one magnotometer.

26. The apparatus of any one of claims 18 to 25 wherein the second sensing device further has at least one gyroscope.

27. The apparatus of any one of claims 18 to 26 wherein the second sensing device further has at least one magnotometer.

28. The apparatus of any one of claims 18 to 27 wherein the second force sensing device further provides data for the calculation of the force for left and right steps and the ratio between left and right steps.

29. The apparatus of any one of claims 18 to 28 wherein the communication device is a wireless communication device.

30. A system for evaluating athletes comprising:

the apparatus of any one of claims 18 to 29; and

software executable on an electronic computing device for receiving the data and computing at least linear velocity, linear acceleration and linear distance travelled.

31. A system for evaluating athletes comprising:

the apparatus of any one of claims 18 to 29; and

software executable on an electronic computing device for receiving the data and computing at least linear velocity, linear acceleration, linear distance travelled, the force for left and right steps and the ratio between left and right steps.

32. A method of calculating at least linear velocity, linear acceleration, linear distance travelled of a weighted resistance towing sled having a force sensing device including at least one accelerometer:

receiving the accelerometer data;

filtering the data to remove noise;

identifying the start of movement; and

calculating linear velocity, linear acceleration, and linear distance travelled from the accelerometer data.

33. The method of claim 32 wherein the method further includes calculating the force for left and right steps and the ratio between left and right steps of a weighted resistance towing sled having a force sensing device including a strain gauge and gyroscope, the method including the steps of:

receiving the strain gauge data;

filtering the data to remove noise;

calculating the force;

receiving the gyroscope data;

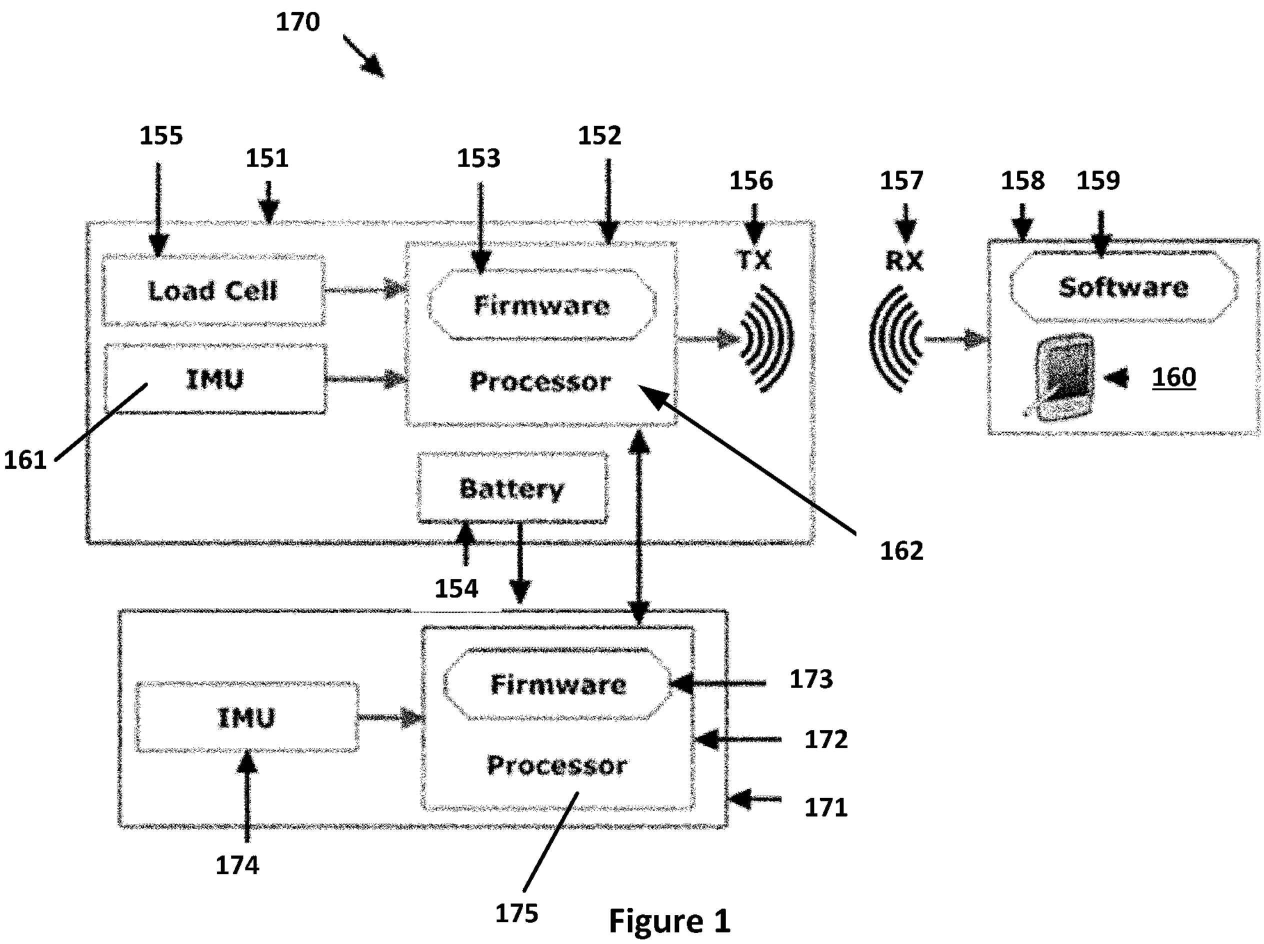
filtering the data to remove noise;

calculating the angle of pull;

calculating from the force and the angle of pull the horizontal and vertical forces;

detecting the steps; and

calculating the force for left and right steps and the ratio between left and right steps.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155
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152
156
157
158
159
TX
RX
Load Cell
Firmware
Software
IMU
Processor
160
161
Battery
162
154
Firmware
173
IMU
172
Processor
171
174
175

Figure 1

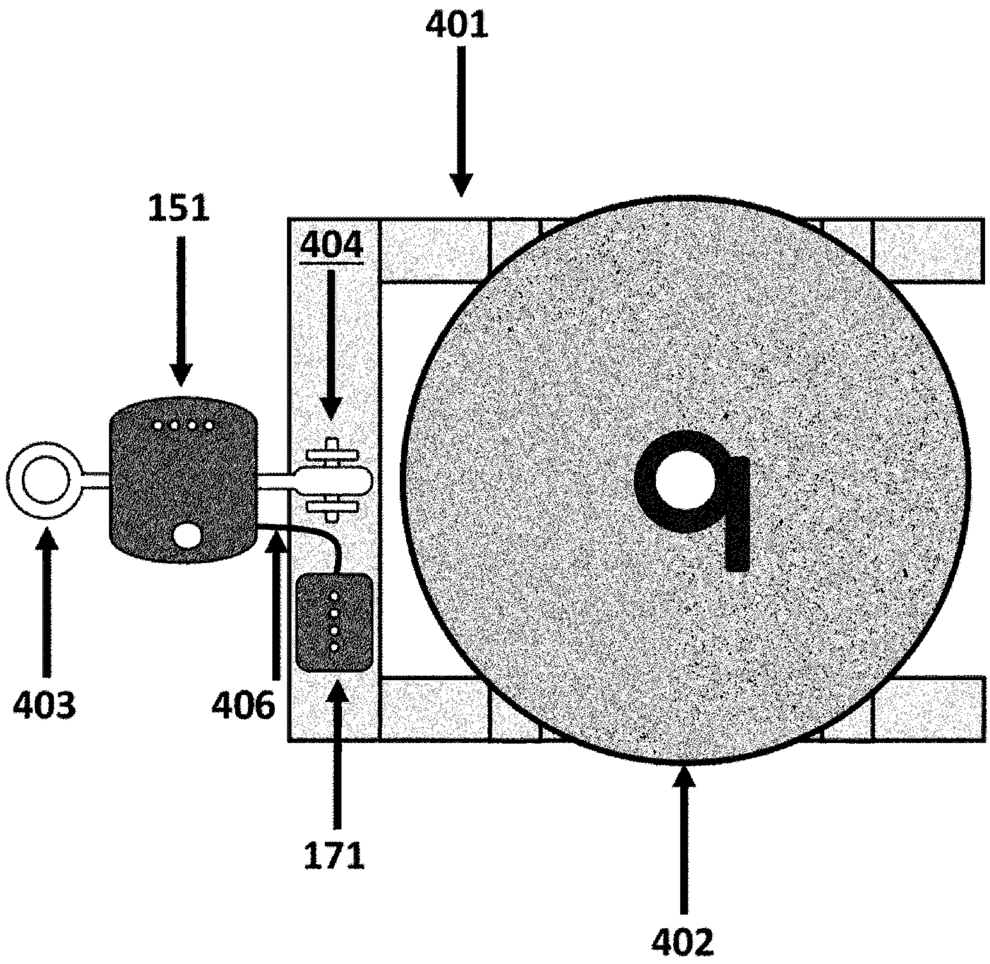

Figure 2

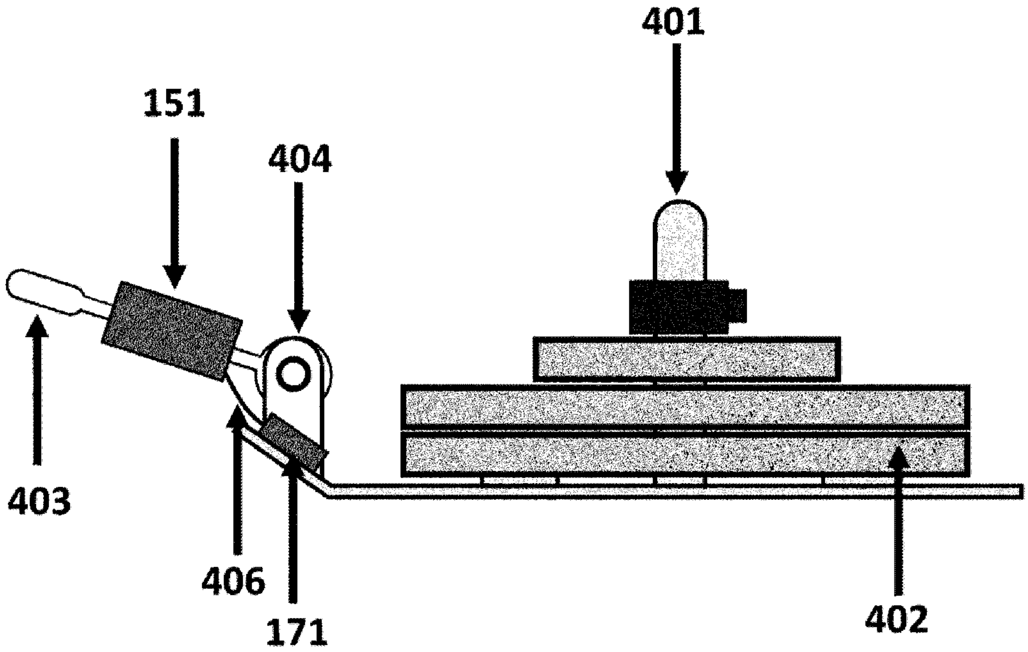

Figure 3

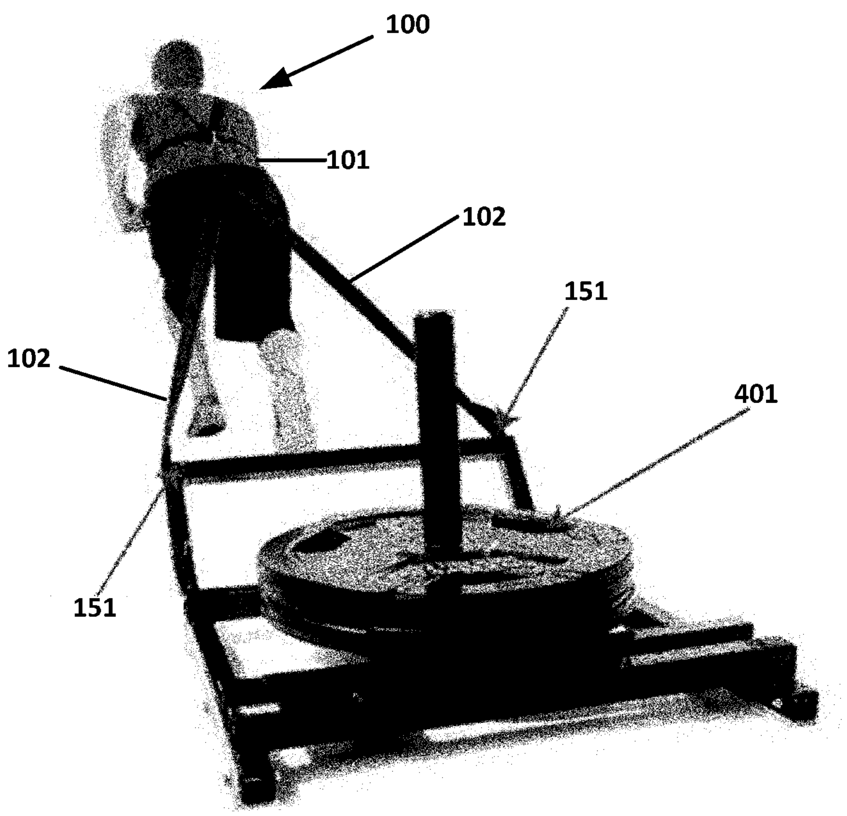

Figure 4

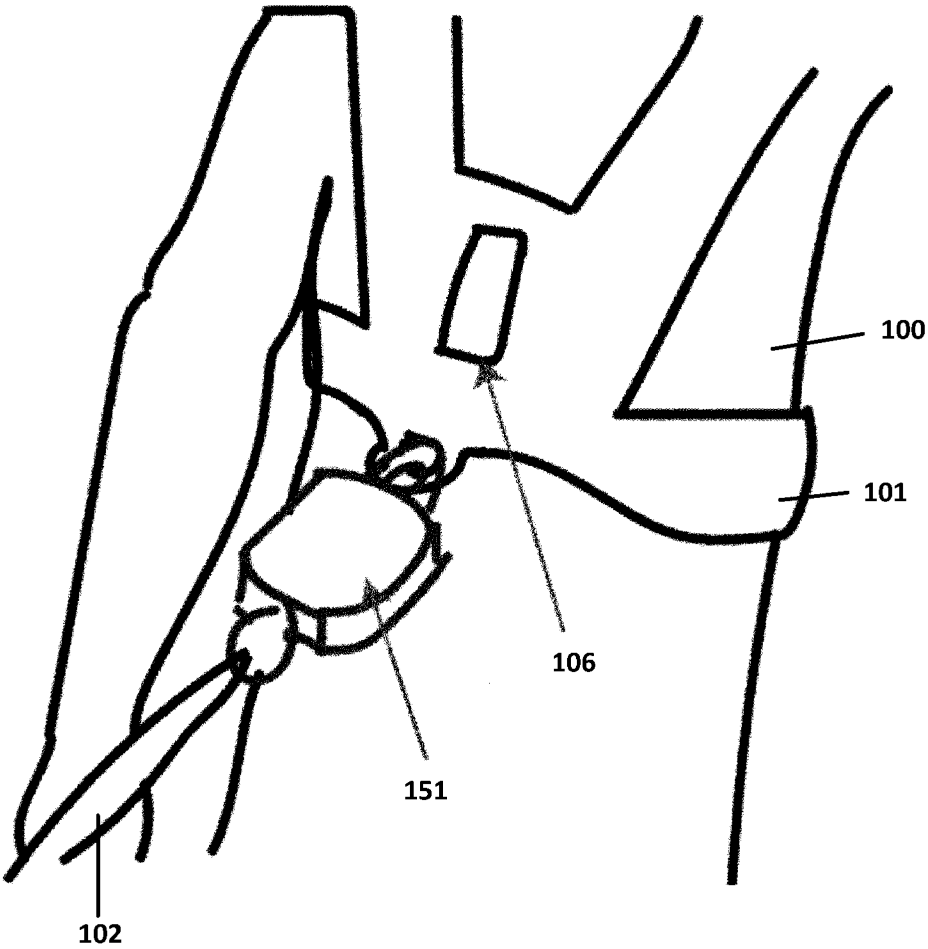

Figure 5

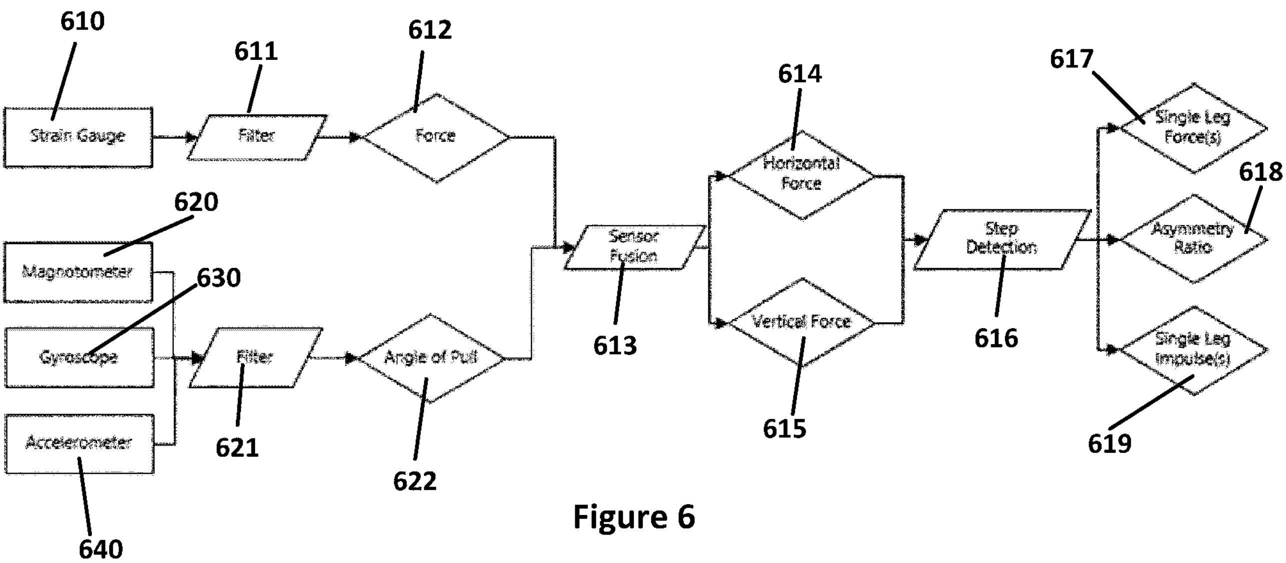

Figure 6

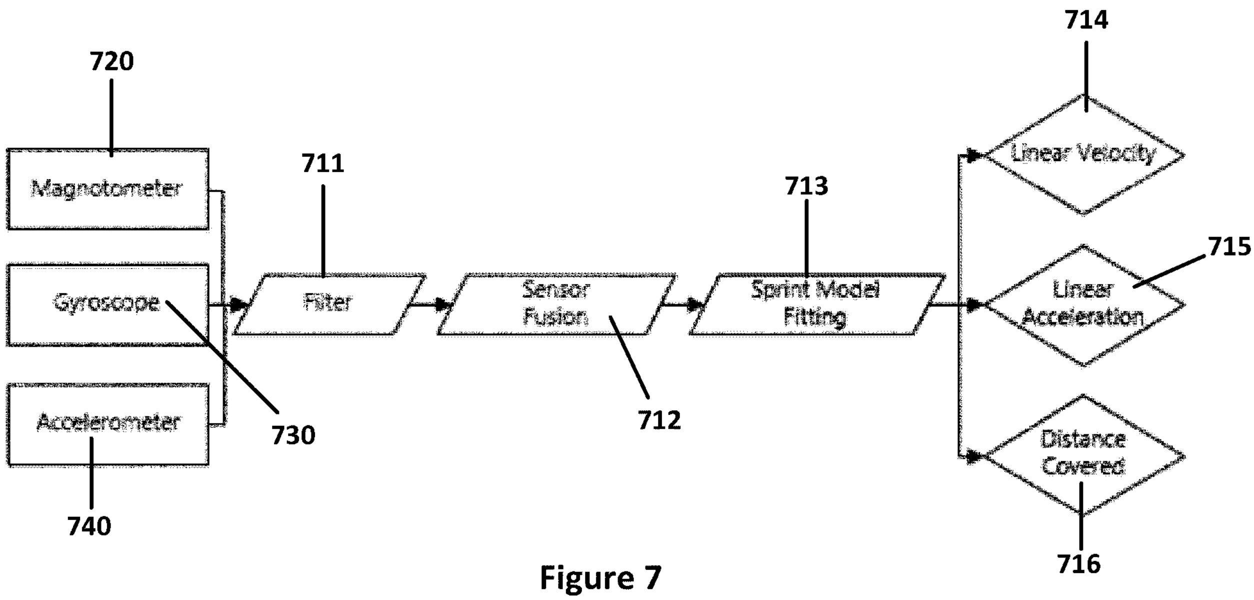

Figure 7

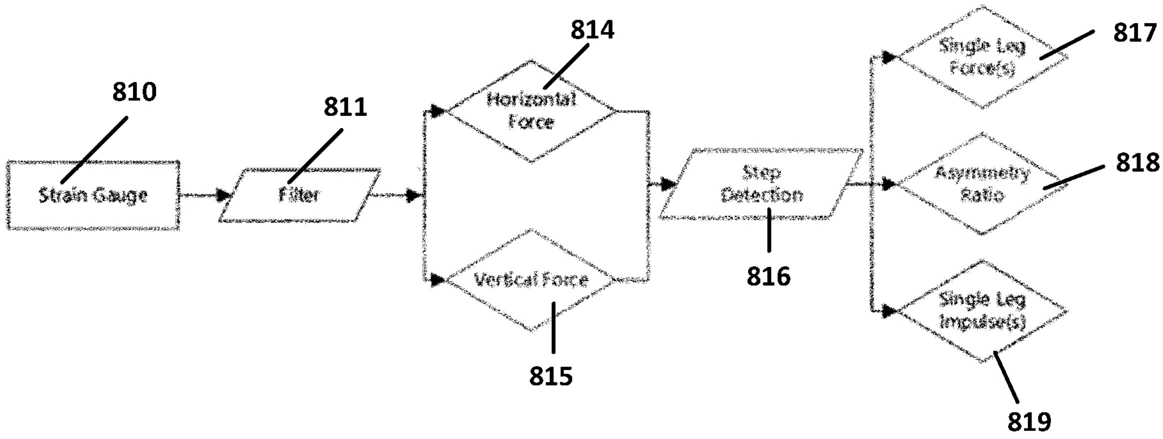
Strain Gauge
810
Filter
811
Horizontal Force
814
Vertical Force
815
Step Detection
816
Single Leg Force(s)
817
Asymmetry Ratio
818
Single Leg Impulse(s)
819

Figure 8

A. CLASSIFICATION OF SUBJECT MATTER

A63B 21/00 (2006.01) A63B 23/00 (2006.01) A63B 22/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Google, Google Scholar, Google Patents, www.freepatentsonline.com, EPOQUE (PATENW) with IPC marks A63B21/00 or A63B23/00: athelete, training, sled, load cell, accelerometer, tow, multiple, sensors, left, right, steps and other similar keywords

Applicant(s)/Inventor(s) name searched in internal databases (PAMS, NOSE, AusPat, INTESS) provided by IP Australia

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 March 2019	26 March 2019

Name and mailing address of the ISA/AU	Authorised officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Andrew Munro AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262850715

INTERNATIONAL SEARCH REPORT	International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT	**PCT/NZ2019/050003**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 2014/0111352 A1 (MADISON J. DOHERTY) 24 April 2014 see, for example, paragraphs [0043]-[0044] and figure 6	1-33
Y	GAFFNEY, M., et. al., "A Highly Automated, Wireless Inertial Measurement Unit Based System for Monitoring Gym-Based Push-Start Training Sessions by Bob-Skeleton Athletes", Sensors and Transducers, vol. 184, issue 1, pages 26-38, 2015 see, for example, the abstract, page 27 column 1 last paragraph and page 27 column 2 first paragraph and figures 2-3, section 4.4.1 Step Detection, section 3.4 – Pre-Processing, section 3.4 – Push-Off Detection, section 3.4 – Integration	1-33
A	CROSS, M., "Force-velocity profiling in sled-resisted sprint training: Determining the optimal conditions for maximizing power" [retrieved from the Internet 15 March 2019] <URL: https://www.researchgate.net/publication/310327623_Force-velocity_profiling_in_sled-resisted_sprint_running_Determining_the_optimal_conditions_for_maximizing_power> published August 2016, DOI: 10.13140/RG.2.2.14322.50883 see, for example, figure 6 and page 53 section 'Equipment'	1-33
A	US 2007/0123389 A1 (MARTIN) 31 May 2007 see, for example, the abstract, paragraph [0008] and claim 1	1-33
A	US 7066865 B2 (RADOW) 27 June 2006 see, for example, the abstract, figure 1A and claim 1	1-33
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A	US 2010/0323848 A1 (WROCLAWSKY) 23 December 2010 see, for example, the abstract, figure 2 and claim 1	1-33
A	WINWOOD, P., et. al., "A Biomechanical Analysis of the Heavy Sprint-Style Sled Pull and Comparison with the Back Squat", International Journal of Sports Science & Coaching, vol.10, issue 5, pages 851–868, 2015, doi:10.1260/1747-9541.10.5.851 see, for example, the abstract, page 855 section 'Instrumentation', page 863 figure 6, page 862 section 'Exercise Kinetics Between Heavy Sled Pull Strides	1-33
A	BINI, R., R., et. al., "A comparison of cycling SRM crank and strain gauge instrumented pedal measures of peak torque, crank angle at peak torque and power output", Procedia Engineering, vol. 13, pages 56-61, 2011, doi:10.1016/j.proeng.2011.05.051 see, for example, the abstract	33

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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		US 7998030 B2	16 Aug 2011

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.