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## Force Plates: Measuring Human Force Production Using Plate Technology

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## Force Plates

### Measuring Human Force Production Using Plate Technology

Force plates are just one of various devices used in the field of biomechanics for dynamometry, and they are used in a variety of settings from rehabilitation to athletics. The purpose of force plates is to measure force production in the body including ground reaction forces, estimated compressive forces, and torques throughout the body. There are many different companies that manufacture force plates, but they are all composed of many strain gauges and piezo-electric crystals. They also measure force-time on three axes (x, y, z), which provides the maximum ability for those using the equipment to measure various types of force production in the body.

Force plate technology is designed for maximum effectiveness at a minimum cost. Both the force plate and the platform are made of fairly lightweight material that is also durable, strong, and cost-efficient. The top plate is typically composed of aluminum alloy while the bottom plate and platform are made of stainless steel, with the differing materials corresponding to the type of stressors are put on the different parts of the force plate (Carr, Chawiche & Ensor, 2006). One particular company, Innervations, which designs and develops equipment for testing as well as for rehabilitation and training of both athletes and patients, has produced a very light-weight and affordable force plate with an aluminum platform as mentioned above, and a carbon fibre top. They advertise their product to weigh only 37.4 lbs with a very low 100 mm height,

and non-slip surface for added safety. The plate itself is not very large (795mm L x 795mm W x 100mm H) making it very portable, and it is powered through a USB port which means it requires no external power source (Innervations, 2013). This is just one example of a type of force plate, but there are many other sizes and features available depending on the company, including some plates that are fixed instead of portable. With all these features, however, the price of force plates still remains relatively low, with the average price typically in the range of 200 to 300 dollars, with small additional expenses for added accessories or extra parts such as handles.

With various companies such as Innervations and others each advertising their force plates and why they are the best, it is important to evaluate and decide what is actually best for your own testing purposes. Different factors must be considered depending on whether you are choosing a force plate for testing balance, testing gait, or performing sport testing, since these are the three main areas of research in which force plates are used. Force plates can also be used either individually or arranged in different patterns, again depending on what is being tested, and they are designed to measure the forces and moments applied to the top surface as the subject stands, steps, or jumps on the plates (AMTI, NA). Thus, force plates can be used for a variety of types of testing, and careful evaluation and research are necessary to ensure the right features are selected when choosing a system.

Some examples of what to consider when choosing a force plate are whether portability is necessary and what size plate will best fit with the way you intend to use the equipment. There are both portable and fixed plates available with standard sizes ranging from 400 x 600mm to 1200 x 1200mm and what is chosen varying depending on the characteristics of the desired testing. Another factor that must be taken into account is the vertical force capacity that will be

required for your particular use. The selected capacity must be able to withstand the largest vertical load that will be applied to the platform, since although force plates are designed with a generous safety margin, damage can occur if the equipment is loaded beyond its capabilities in any axis. Before choosing a plate, therefore, the extremes of all force and moment components of the desired testing should be examined and taken into account as important deciding factors. Also, the level of accuracy expected in your testing must also be determined before choosing a plate, since this has the potential to greatly limit your options if you must have a very high level of accuracy (AMTI, NA). As can be seen, there are multiple important factors to consider when choosing a force plate, but there are also various options from which to choose in order to best fit your own desired testing needs.

As was mentioned previously, force plates are used in a variety of settings to serve various purposes. One very common example of this is their use in sport performance to measure the forces applied by an athlete during various skills in order to quantitatively evaluate an athlete's performance. The plates measure the ground reaction force in three planes to give the coaches a detailed idea of their athletes' interaction with the ground. The ground reaction forces that are measured, along with other variables provided by the force plates, have been seen to have moderate relationships with a variety of other performance measures such as one maximum repetition back squat, agility, and sprint performance. Some examples of measures that have been studied are jump height for countermovement and static jumps at various loads, instantaneous force measured in the isometric mid-thigh pull, weight distribution asymmetry between right and left legs during the barbell back squat, various rate-of-force development measures across multiple plyometric exercises, isometric peak force measured at three key conventional deadlift positions and the isometric mid-thigh pull (Beckham, Suchomel &

Mizuguchi, 2014). Thus, force plates are very useful in providing coaches with data from testing of their athletes to better all areas of performance.

Another area in which force plates are used is in rehabilitation settings such as in performing a gait analysis. This analysis typically includes a discussion of the patient's present as well as prior training patterns along with his/her present and prior injuries. It also includes an examination of the patient's strength, flexibility and balance along with studying of shoe wear patterns and a visual analysis of movement patterns during walking and running. From this analysis, the rehab professional is able to provide the patient with patterns of movement deficiency that have been observed and could be contributing to on-going as well as acute injury. The patient is then provided with ways in which to correct these improper movement patterns to avoid further injury and aid in recovery (Professional Physical Therapy, 2014).

Force plates play an integral part in gait analysis. They provide data on foot pressure and allow the subject to walk normally when a walkway, which is one of the key components in an effective force vector system, is used to obtain the most accurate results of the client's normal gait. Force plate technology can also be combined with other types of video and recording systems to provide an even more detailed and thorough analysis. This may include live images of vector data as the patient walks across the force plate, and this data can then be saved and used later for most effective analysis. The reports from this data are fully customizable, and any part can be abstracted for further discussion with the client (zFlo, 2015). Force plate technology alone, as well as combined with other types of analysis systems, provides increased ease and precision in the analysis of gait for rehabilitation settings.

Another area in which force plates are used is in testing prosthetic limbs, particularly in the lower extremity, to determine overall effectiveness, help best meet the individual needs of the

patient, and ensure that prosthetic training is delivering the desired results. One such study evaluated 15 transfemoral amputation patients, 12 men and 3 women, between the ages of 49 and 75 during prosthetic training. The aim of this study was to examine the changes in floor reaction forces through the prosthesis during a stationary stance as well as active gait analysis. The study states how this was carried out with the following: “As the patients were standing and walking in parallel bars at free speed, ground reaction forces were measured with a force plate and gait velocity was measured using two photocells.” Three variables suggested considerable improvement of locomotion and gait training for the amputee patients observed in this study including static weightbearing, gait velocity, and vertical loading of the prosthesis during gait (Gauthier-Gagnon, Gravel, St-Amand, Murie, & Goyette, 2000). From the results of studies such as this, the quality of life and of medical care for those with prosthetics can be maximized, and force plates play an integral role in this process by providing the hard data to effectively evaluate and alter the care being given.

Although force plates and their uses are not widely known or discussed in everyday settings, they are used significantly in the health field from enhancing sport performance, to maximizing rehabilitation goals, to evaluating prosthetic limbs. There are many different options to consider when choosing a force plate, depending on the type of testing you wish to perform, and there are many choices offered by various companies. Force plate testing is also relatively inexpensive and thus is virtually available to any setting in which it could prove useful.

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