# Cost Effective Solution for Educational Tools in Developing Countries: A Pilot Study on Continuous Force Measurement Instrumentation

## Gelişmekte Olan Ülkeler İçin, Maliyet Etkin Eğitim Araç Çözümü: Sürekli Kuvvet Ölçüm İnstrümentasyonu Üzerine Pilot Çalışma

Rafet IRMAK,[a]
Ahsen IRMAK[a]

[a]Department of Physical Medicine and Rehabilitation,
Mevlana University
Health Services High School, Konya

Geliş Tarihi/*Received:* 07.10.2013
Kabul Tarihi/*Accepted:* 13.01.2014

*This study was presented at IV[th] Exercise physiology symposium, 17-18 May 2013, İstanbul, TURKEY*

Yazışma Adresi/*Correspondence:*
Rafet IRMAK
Mevlana University
Health Services High School,
Department of Physical Medicine and Rehabilitation, Konya,
TÜRKİYE/TURKEY
rafetirmak@gmail.com

**ABSTRACT Objective:** The use of new technologies in sports physiotherapy has reflections on sports physiotherapy education. Experimental practice on new technologies has contribution to clinical practice of physiotherapy students. There are also products in the market for this purpose. These products have excessive financial load on budget of physiotherapy schools. Do it yourself projects may be a solution for financial problems. Force measurement is an important topic in sports physiotherapy education. Continuous force measurements systems are new and expensive tools. The purpose of this study is to construct a continuous force measurement tool for educational purpose in a cost effective way. **Material and Methods:** S-type load cell was used as force transducer. Amplification was performed with an instrumentation amplifier. Data acquisition was performed with a USB DAQ card. **Results:** It has been succeed to construct a continuous force measurement tool for educational purpose only for 78 USD. **Conclusion:** Cheap Do it Yourself applications may contribute to decrease expenditure of experimental education methods in developing countries for experimental education of new technologies.

**Key Words:** Cost effectiveness; loadcell; force measurement; physiotheraphy

**ÖZET Amaç:** Yeni teknolojilerin spor fizyoterapistliğinde kullanımının, spor fizyoterapistliği eğitimine de yansımaları vardır. Yeni teknolojiler üzerine deneysel deneyim, fizyoterapi öğrencilerinin klinik uygulamalarına katkı sağlamaktadır. Bu amaçla, pazarda hâlihazırda ürünler vardır. Bu ürünler, fizyoterapi okullarının bütçeleri üzerinde aşırı bir yüke neden olur. Kendin yap projeleri, bu finansman sorununa bir çözüm olabilir. Kuvvet ölçümü spor fizyoterapistliği eğitiminde önemli bir yere sahiptir. Sürekli kuvvet ölçüm sistemleri yeni ve pahalı araçlardır. Bu çalışmanın amacı, sürekli ölçüm sistemini maliyet etkin bir yolla geliştirmektir. **Gereç ve Yöntemler:** Kuvvet transduseri olarak S tipi yük hücresi kullanılmıştır. Amplifikasyon instrümentasyonel amplifikatör kullanılarak gerçekleştirilmiştir. Veri kaydı, usb DAQ kartı kullanılarak gerçekleştirilmiştir. **Bulgular:** Çalışma sonunda, eğitim amaçlı sürekli kuvvet ölçüm kitini, 78 dolara geliştirmek mümkün olmuştur. **Sonuç:** Ucuz, kendin yap projeleri, gelişmekte olan ülkelerde yeni teknolojilerin deneysel eğitimi için gerekli olup, deneysel eğitim metotlarının maliyetlerinin azaltılmasına katkıda bulunabilir.

**Anahtar Kelimeler:** Maliyet etkinlik; yük hücresi; kuvvet ölçümü; fizyoterapi

**Turkiye Klinikleri J Sports Sci 2014;6(1):24-7**

The use of new technologies in sports physiotherapy and rehabilitation departments increase day by day. This trend has also reflections in education of sports physiotherapist. There are different type of experimental education sets for exercise physiology and biomechanics in the market.

Experimental practices on new technologies by experimental student sets have important contribution to develop a foundation for clinical prac-

tice.[1-4] One of the important difficulty to include this education method in the program of physiotherapy schools in developing countries is the excessive financial load on school budgets.

Do it yourself (DIY) projects may be a solution for this problem.[5] Educational tools do not need high precision and reliability as clinical or research tools. In educational sets main idea is to learn how the instrument is working, to learn the error sources on measurement and operation and to gain the ability to use the technology. The tools developed by DIY approach have ability to cover both topics and also can help to decrease the budget.

Surface electromyography (sEMG), electrogoniometers and force measurement tools are popular applications in experimental student education sets which are directly related in physiotherapy practice.

Construction of sEMG amplifier needs advanced knowledge on amplifier design and special skills like surface mount device (SMD) soldering. It is possible to find designs for electrogoniometers by different transducers in the literature.[6-8] These designs may be simplified for use in educational purpose. The force measurement tools are medium level application and it may be difficult to find sample applications. Also force measurement is an important diagnostic tool in physiotherapy practice.[9] There are different options in the market between conventional dynamometers to force plates and isokinetic dynamometers.

Continuous force measurement dynamometers are new and expensive options in the market. In spite of the classical approach (peak force measurement), these tools measure the force and store or transmit the data to a computer. Sport physiotherapist can evaluate force production of the skeletal muscle in each time interval of the contraction. And also these tools can be synchronized with sEMG or electrogoniometers and, force production can be investigated by joint position and sEMG activity.

The purpose of this study is to share knowledge on how a continuous force measurement tool can be setup for educational purpose in a cost-effective way.

## MATERIAL AND METHODS

A biophysical force measurement system consists of four components. Force transducer, amplifier, data acquisition device and data logging device.

For continuous force measurement applications load cells are basic solutions. Load cells are devices which convert force to an analog electrical signal. There are different types of load cells for different purposes. S-type load cells may be the appropriate solution for multipurpose applications in physiotherapy. Because they have ability to measure both tension and compression (flexion-extension) forces.

A HC-C3 S-type (Zemic, Etten-Leur/ Netherlands) loadcell was used in this study with two rings and straps. Rings and straps were used for load cell mounting (Figure 1).

The output signal of a load cell is so small and has to be amplified to recognize by data acquisition device. An instrumentation amplifier and constant +5 V voltage supply (LM1167 and LM7805 respectively) was used for amplification. USB-1608FS DAQ card (Measurement Computing, Norton/ USA) and its software was used for data acquisition and recording (Figure 1).

Calibration was done by a reference electronic dynamometer with 20 gram sensitivity (Dikomsan DGC 50, Istanbul/Turkey).

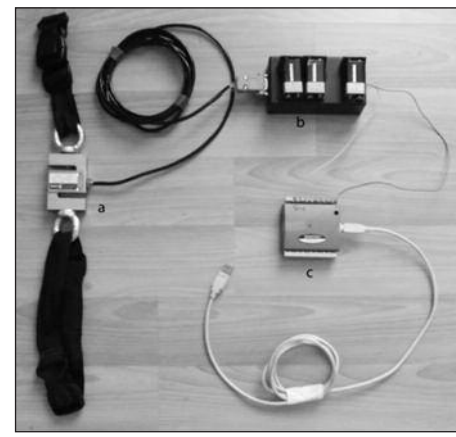


**FIGURE 1:** Force transducer; **a:** loadcell and its mounting kit, **b:**amplifier, **c:** DAQ card.

## RESULTS

The total expenditure of the material used for force transducer is 78 USD (60 USD for load cell, 8 USD for integrated circuits and 10 USD for mounting kit). The system was constructed by the author. There was no expenditure for construction.

A sample calibration is done between 0,7 to 4,4 KgF (Figure 2). Standard error of estimate is 0,348 and $R^2$ is 0,999.

Sample measurement setup for quadriceps muscle is shown in Figure 3a. Onset of muscle force production, peak force production, time to peak force production can be clearly identified (Figure 3b).

## DISCUSSION

Supremacy of continuous force measurement systems on classical dynamometers is measurement of peak and mean force outputs in time intervals. The developed system can measure force output at 3 Ksample/sec. This gives the user to increase the time interval sensity to 1/3000 seconds. This is a very high resolution upon commercial solutions (100 sample/sec) in the market.

In this study mounting kit was designed especially for lower extremity and trunk muscles. Also transducer was selected for this purpose. 20 kgf and 50 kgf transducers can be used for upper extremity muscles with appropriate mounting kit desing.

Experimental practices on new technologies have important contribution to clinical practice.[1,2] The expenditure for experimental student sets have excessive financial load on school budgets in developing countries. Continuous force measurement tools are medium level applications for construction.

## CONCLUSION

In this study experience was shared on how a cheap continuous force measurement transducer can be constructed for educational purpose. Cheap DIY applications may contribute to decrease expenditure of experimental education methods in developing countries for experimental education.

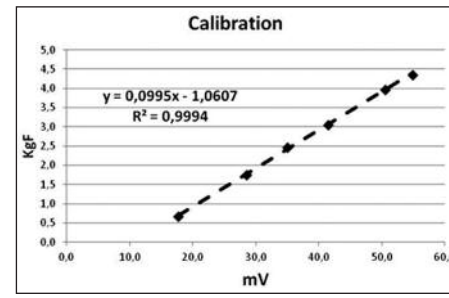


**FIGURE 2:** A sample calibration between 0,7 Kgf-4,4Kgf.

**FIGURE 3a:** Force measurement in sitting position for quadriceps muscle.

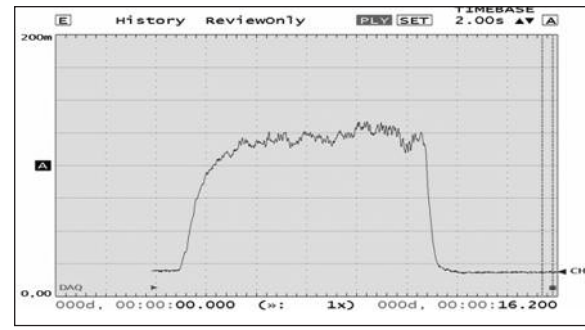


**FIGURE 3b:** Isometric contraction curve of quadriceps muscle in sitting position. Recording was captured under TracerDAQ software. (y axis miliVolt, x axis second.)

### *Acknowledgement*

*The amplifier circuit was designed by A. Ruhi SOYLU.*

## REFERENCES


1. Carvalho H, West CA. Voluntary participation in an active learning exercise leads to a better understanding of physiology. Adv Physiol Educ 2011;35(1):53-8.
2. McNeal AP, Silverthorn DU, Stratton DB. Involving students in experimental design: three approaches. Am J Physiol 1998;275(6 Pt 2):S28-34.
3. Castro-Sánchez AM, Aguilar-Ferrándiz ME, Matarán-Peñarrocha GA, Iglesias-Alonso AA, Fernández-Fernández MJ, Moreno-Lorenzo CC. Problem based learning approaches to the technology education of physical therapy students. Med Teach 2012;34(1):e29-45.
4. Wolf FM. Lessons to be learned from evidence-based medicine: practice and promise of evidence-based medicine and evidence-based education. Med Teach 2000;22(3):251-9.
5. Bhaskar A, Tharion E, Devasahayam SR. Computer-based inexpensive surface electromyography recording for a student laboratory. Adv Physiol Educ 2007;31(2):242-3.
6. Wang PT, King CE, Do AH, Nenadic Z. A durable, low-cost electrogoniometer for dynamic measurement of joint trajectories. Med Eng Phys 2011;33(5):546-52.
7. Bronner S, Agraharasamakulam S, Ojofeitimi S. Reliability and validity of a new ankle electrogoniometer. J Med Eng Technol 2010;34(5-6):350-5.
8. Shiratsu A, Coury HJ. Reliability and accuracy of different sensors of a flexible electrogoniometer. Clin Biomech (Bristol, Avon) 2003;18(7):682-4.
9. Koz M, Ersöz G. [Importance of physical and muscular fitness in prevention of sports injuries]. Turkiye Klinikleri J Orthop & Traumatol-Special Topics 2010;3(1):14-9.