CHAPTER– 9
CONCLUSIONS AND SCOPE OF FUTURE RESEARCH

9.1 Overall conclusions

In this work physical strength variables were measured in the age group of 14 to 30 years. Strength was reduced with increasing age in both men and women subject. Measurement of Punch, Pinch, and Hand–grip and Back strengths along with various physiological tests will help coaches, trainers and also hand surgeons to assess physical strength along with some factors specially hand function.

Punch strength measurement

In this study, the punch force generated was quite low for the novice boxers, while using Syscon load cell in experimental study when compared to the FE simulations. The reasons of this difference may be attributed to the selection of contact area between punch pad and load Cell, material properties, material thickness, stress and strain effects of the punch pad.

Mean maximal punch forces for the rear (right) fist of male novice boxers were (average 170.8 N) significantly greater than lead (left) fist (average 135.8 N) of not wearing gloves of novice boxer. Punch forces of rear (right) fist of male novice boxers were 26% higher in comparison to lead (left) fist.

Designed Load cell

The load cell designed and fabricated based on a stain gauge for boxing dynamometer was more suitable to Indian Boxer for the measurement and discrimination of the punch force accurately and effectively between Professional and Novice boxers’ performance, and also between rear and lead fist punch deliveries as it was closed to the range of the force generated. The comparison of experimental data of punch force using the specially designed load cell tallied with the finite element modeling results indicated that experimental value of $F_{\text{max}}$ was 166 N where as $F_{\text{max}}$ of 185 N was obtained from the FE analysis, keeping the same (0.61 m) distance for punch. Hence, the experimental and FE results were matched significantly with the punch force by the rear (right) hand (170.8 N)
and lead (left) hand (135.8 N) for novice boxers. It shows that punch forces of the novice boxers were quite low compared to the FE simulations. The reasons of this difference may be attributed from the selection of equivalent hand mass, arm and fist material properties, skin thickness and visco-elastic effects of the punch pad and also the kinaesthetic perceptions (Pierce et. al., 2006; Smith et. al., 2000; Villani and Preli, 2003). Mean maximal punch forces for the rear (right) straight punch were significantly greater than lead (left) fist and arm of hand of without wearing glove of novice Boxer (Ghosh et. al., 2009) although punch distance is same.

**Pinch strength measurements**

The hand pinch dynamometer made indigenously that is more suitable, capable of producing accurate and realistic force measurements of youth and normal sportspersons and also injured sportspersons as well as orthopedic patients for the evaluation and quantification of the pinch force. The experimental results showed that the force sensor presents a minimum inter-subject and inter-trial variability, and a good inter-trial repeatability. With the designed dynamometer, average pinch forces were obtained as 24.8 N and 21.9 N for male and female subjects respectively.

**Hand–Grip strength measurement**

The results of the hand–grip strength measurements were comparable with existing results tested using the sophisticated Hand–grip measuring instruments. Final average grip forces were obtained as 261 N and 203 N for Indian male and female respectively, specially for the people from Eastern and Northeastern region.
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Back strength measurement
This study of back strength measurements using a simple hand back strength dynamometer was very much relevant to the physical strength measuring parameters of Indian sportspersons including boxers. Final average back strength was obtained as 294.7 N and 284 N for Indian male and female respectively. Back strength of male students was 7% higher than female students and male sportspersons was 7% higher in comparison to female sportspersons, whereas male boxers were 8% higher than female boxers. The experimental results showed that this back force dynamometer had minimum inter–subject and inter–trial variability, and a good inter–trial repeatability.

Body mass index and body fat percentage measurements
Average body fat percentage of Indian male youth was moderate and also for women youth was moderate except female boxers whose fat percentage was on higher side. It may be due to measurement of percentage of body fat of less number of female boxers. BMI and body fat percentage of the youth helped for identification of whether sportspersons including boxers and students were normal, under or over weight. Average BMI of all category of male female were 20.72 and 21.75 kg/m². Mean Body fat percentage of male students, Sportspersons and boxers groups (13.86) were less than female groups (25.51).

Blood pressure and pulse rate measurements
The indigenously developed pressure sensor is more suitable and capable of producing accurate blood pressure. The experimental results revealed that both the devices i.e. Sphygmomanometer and Pressure sensor indicated same uniformity and repeatability when pressure was changing. Pulse rate measurements were studied for the same group of subjects for the evaluation and quantification of the pulse rate accurately. The experimental results showed that the calibrated pulse rate monitor indicated accurate results. The mean systolic BP of male boxers was 131.2 mm–Hg and for the female boxers was 127.2 mm–Hg. On the other hand, diastolic BP of male boxers was 99.4 mm–Hg and for female boxers was 90.2 mm–Hg.
Average Pulse rate (92) of male boxer group was greater than female (87). Average pulse rate of male sportspersons was 6% higher in comparison to female sportspersons. In case of boxers, male boxers were 9% higher than female boxers.

Determination of physical strength as well as physiological parameters through quantification not only enhances the health status of all the youth in the sports and medical field but also inculcate the health status attitude among the youth. This study will be a motivation for sports as well as medical fraternity to study the physical strength of youth before participation of their competition. The biggest advantage of these types of physical strength and its correlated factors measurements in any sports as well as medical organization will increase productivity of the youth in the society.

9.2 Scope of future research

Computerized program may be designed with punch, pinch, grip and back dynamometers along with load cell and pressure sensor for data acquisition and analysis, in order to record and monitor real time force signals by considering the availability of the accessories mainly sensor system with affordable cost. The physical parameters of various forces need to be A/D converted and made noise free and fed to a computer having proper software for the purpose. The results are useful for biomechanical modeling of the fingers and hands, for designing ergonomic tools’ fingers and hand grips, and for evaluating fingers as well as hands function.

Punch strength measurement and Designed Load cell

In depth studies from wider range of Indian male as well as female boxers are needed to pickup right boxers for specific boxing field from appropriate community. Digitized indicator for the load cell and also attachment of computer system may be designed for collection and storing the data of punching force easily.
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Pinch, Hand–grip and Back strength measurements
The indigenously developed pinch dynamometer may be modified into a highly modular system to facilitate the further application to kinetic experimentation and hand injury rehabilitation. Surface area of the pinch point may be increased so that subjects may get more comfort while pinching.

Various groups of sportspersons as well as patients with finger, hand, spinal injury can be selected for proper quantification and evaluation of the pinch, hand and back strength. In depth studies based on wider range of Indian normal male and female and sportspersons especially injured as well as orthopedic patients may be performed. These mechanically designed dynamometers can be developed by computerized data acquisition systems for data acquisition and analysis for real time signals during experimentation.

BMI, Body fat %, BP and Pulse rate measurements
The measurements can be extended to a large number of groups such as highhypertension and diabetic and high cholesterol patients for the quantification and evaluation of the BMI and body fat % accurately. Pressure sensor can be modified in to digital system so that it can be connected with computer system for getting real–time data easily.