AN INNOVATIVE DEVICE FOR MEASURING THE ACCURACY OF THROWING IN HANDBALL

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INTRODUCTION: The accuracy in hitting the target and ball velocity are the two determining factors for scoring in a team handball game. A digital electronic device was constructed in order to measure the accuracy of throwing in handball. This innovative device consists of two parts: a) the central unit which generates visual stimuli and collects data and b) the tabloids.

METHODS: Hardware Specification: The device consists of three independent tabloids placed inside and connected to the handball goal post (Fig. 1). The dimensions of the two vertical tabloids are 200x60x2cm, and those of the horizontal 180×60×2cm. The dimensions of the goal post are 300×200×8 cm, constituting a total surface of 60,000 cm,^{2} of which 38,400 cm^2 are covered by the tabloids.

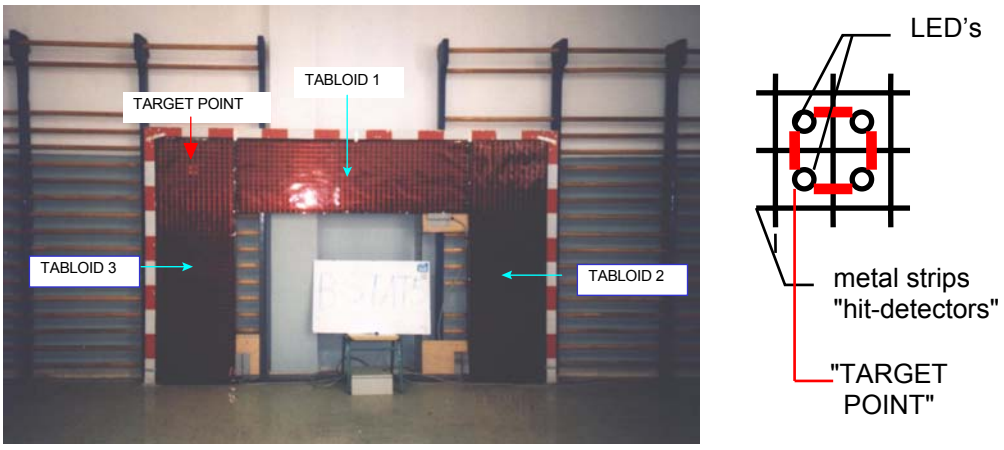

Fig. 1. Part of the electronic device for the measurement of accuracy of throwing in handball. The three tabloids placed inside and connected to the handball goal post with a lit up "target point."

A total of 2,130 holes were made on all three tabloids. An equivalent number of light emitting diodes (LED) were placed in the back side of each tabloid into each hole so that they would be visible on the front side. The LEDs were placed in such a way as to form a net of squares (40×40mm). One of these squares, when illuminated, determined the "target-point" to be hit in a throw (shot) (Fig. 1).The "target point" was randomly varied for each shot. The net of LEDs was interwoven

with metal strips (10mm wide and 1 mm thick) which laid at a distance of ≈ 2 mm from each other forming another net of squares (40×40mm). These strips served as "hit-detectors."
When the ball hits a specific point on the metal strips, an electrical contact is produced which is transferred to the central processor unit (CPU), after having been processed by the multiplexer - demultiplexer unit which was placed between the CPU and the tabloids to split the input and output signals. The electronic scheme of this unit is shown in Fig. 3. In this way the coordinates of the point hit by the ball are registered with very high accuracy. The largest error in hit-detection (i.e., the largest distance from the strip) occurs in the case of the ball hitting the LED's (i.e., at a distance 20 mm × √ 2 = 28,3 mm from the angle of the square formed by the metal strips).
The data from the CPU was transferred via a serial communication port (RS 232) to a portable P/C interfaced with the CPU and was processed by the use of proper software. The interface of the P/C with the device was programmed as follows : baud rate 4800, data bits 8, stop bits 1, parity none.

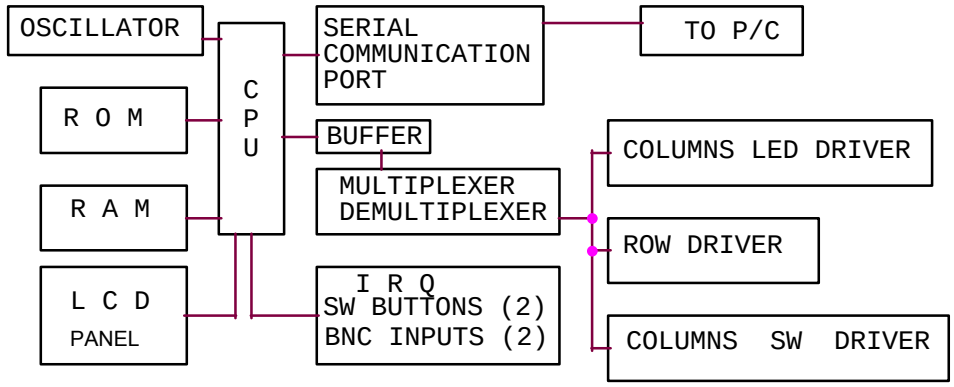

Fig 2. Electronic configuration of visual stimuli generator and throwing data collection unit

Software Specifications: This data collection system is based on the INTEL 8085 micro-processor, which in combination with the other regional units (serial communication port, L.C.D. panel, ROM and RAM 32 Kbytes,) comprises the integrated control device (Fig. 2).
The software programming of the system and the depiction of data was based on three (3) parts:

1) part for testing the "target points" and "hit detectors"
2) part for reading the system's random access memory (RAM)
3) part for storing the application function (ROM).

The menu options were selected by the use of two buttons (START/STOP and NEXT) and the selected option was depicted on an LCD panel.
The efforts of the handball players to hit the "target point" were depicted on the LCD with the following display form:

T1>MMMMmsec -KKK-D
T2>MMMMmsec -XXX-T

T3>MMMMmsec -NNN
T4>MMMMmsec -QQQ

Where:

Ö1: the time point of the first hit on the tabloid

Ô2: the time point at which the ball left the last "hit detector"

Ô3 and Ô4: there was capacity for registration of two more time points which, however, were not used in this study.

MMMM: time in msec (0 - 9999)

KKK**:** the number of the "hit detector" hit first (0 - 671).

D**:** the number of the tabloid hit first (1 - 3).

T**:** the number of the tabloid where the "target point" lit up (1 - 3).

XXX: the number of the "target point" lit up (0 - 671).

NNN**:** the number of the subject performing the hitting attempt (0 - 255).

QQQ: the number of the hitting attempt (0 - 1500).

The hitting attempt was registered only if the ball hit a "hit detector." As soon as a "hit detector" was hit the lit up "target point" went off. The results of the hitting attempt obtained in the form described above remained on the LCD panel after the completion of the athlete's effort.

The system's memory had the capacity to store up to 1500 attempts. A capacity of 16 bytes was used for the registration of each attempt. Thus, the total storing capacity of the system (RAM) was 24000 bytes (1500 attempts X 16 bytes). All bytes were in binary form except for the tabloids numbers, which were in ASCII form (31H - 33H). When resetting the system the registration of the hitting attempts was restarted. The same happened when the maximum number characterizing the subject performing the hitting attempt was exceeded (i.e., when NNN>255).

The system's memory was divided into: a) memory of permanent data storing (EPROM), which was 32KB ROM, and b) memory of temporary data storing, which was 32KB RAM. The control program of the system was in the former memory, while the registration of the hitting attempts was stored in the latter memory.

CONCLUSIONS: With the device described in the present study it was possible to register the following : a) the coordinates of the lit up "target-point" on the tabloid, visually displaying the beginning of the throwing attempt, b) the coordinates of the contact point on the tabloid hit by the ball, c) the duration of the contact with an accuracy of 5ms and d) the time elapsing from the visual stimulus until the contact of the ball on the tabloid.

The implementation of this innovative device was completed with measurements taken from athletes of various levels in the field of handball. Furthermore, the application of this device can be expanded to measurements made in other sport involving throwing a ball (e.g., soccer, tennis, baseball, volleyball, etc.).

Fig. 3. Schematic of signals conditioning electronics.