Universitatea *Transilvania* din Braşov

HABILITATION THESIS

METHODS AND TECHNIQUES FOR MEASURING AND ASSESSING HUMAN PERFORMANCE

Domain: PHYSICAL EDUCATION AND SPORT SCIENCE

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BRASOV, 2015

CONTENT

List of notations

MGM – Miron Georgescu modified test;
T-test – Student test;
BPR – Business Process Reengineering;
AUP - Average Unit Power;
AFH - Average Flying Height;
RR - Repetition Rate;
CVE - Energetical variability coefficient;
CVS - Structural variability coefficient;
P_i – participant I;
TLVJ – two legged vertical jumping;
RLVJ – right legged vertical jumping;
LLVJ - left legged vertical jumping;
PS – plantar surface;
F- disperssion ratio;
BMI- body mass index;
PI – ponderal index;
3D – three dimensions;
IR – infrared;
EMG – electromyography.

SECTION A

REZUMAT

Teza de abilitare intitulată “Metode şi tehnici de măsurare şi evaluare a performanţei umane” cuprinde principalele preocupări ale candidatului şi direcţiile de cercetare pe care acesta le-a abordat după obţinerea titlului de doctor.

Aria de expertiză şi temele de cercetare sunt încadrate în domeniul vast al Ştiinţei sportului şi educaţiei fizice, dar şi în domenii interdisciplinare, aducând astfel elemente de noutate şi posibilităţi de explorare a performanţei umane folosind cele mai noi tehnici de achiziţie şi prelucrare de date.

Teza de abilitare este structurată în două părţi. În prima parte sunt prezentate realizările candidatului grupate pe direcţii de cercetare, după obţinerea titlului ştiinţific de doctor.

A doua parte a tezei de abilitare cuprinde direcţiile viitoare de cercetare şi oportunităţile oferite de instrumentele noi pe care candidatul le-a creat în scopul evaluării performanţei umane.

În anul 2008 candidatul a susţinut teza de doctorat cu titlul “Eficienţa folosirii mijloacelor audio-vizuale în cadrul lecţiilor de educaţie fizică cu elevii treptei gimnaziale” şi a obţinut titlul de doctor în Republica Moldova, titlu ce a fost atestat ulterior de către CNATDCU şi în România.

După obţinerea titlului de doctor, candidatul şi-a definit direcţiile de cercetare şi şi-a putut canaliza energia şi ideile către obiective reale, realiste şi fezabile, astfel încât să-şi atingă maturitatea de cercetător.

Principalele direcţii de cercetare sunt prezentate în prima parte a tezei de abilitare. Au fost identificat şase direcţii de cercetare, care dau şi titlurile capitolelor din această parte a tezei, după cum urmează:

1. Eficienţa folosirii mijloacelor neconvenţionale în lecţia de educaţie fizică. Îmbunătăţirea abilităţilor neuro-motorii şi preceptiv senzoriale. Noi abordări ale lecţiei de educaţie fizică şi ale managementului sportiv.
2. Studii privind particularităţile sportivilor pe baza parametrilor energetici şi de control determinaţi în timpul probei „Miron Georgescu” modificată (MGM);
3. Studii privind biomecanica sportului cu ajutorul senzorului Kinect;
4. Modele virtuale ale membrelor inferioare şi superioare. Studii privind estimarea forţei dezvoltate de muşchi;
5. Proiectarea şi construcţia unui dispozitiv pentru evaluarea lateralităţii;
6. Proiectarea şi construcţia unui dispozitiv de monitorizare a deprinderilor specifice atletismului în condiţii reale de manifestare.

Primul capitol prezintă realizările candidatului în domeniul tezei de doctorat, prin studiile legate de modul în care mijloacele audio-vizuale au influenţă asupra unor parametri funcţionali, precum pulsul, tensiunea arterială, capacitatea vitală etc., dar şi asupra stimulării psiho-motorii şi a capacităţii de recpţionare şi însuşire a informaţiilor.

Alte studii prezentate în acest capitol vizează noi abordări ale continutului lecţiei de educaţie fizică bazate pe calculul opraţional şi pe teoria jocurilor, dar şi noi abordări ale managementului sportiv pornind de la principiile BPR (Business Process Reengineering), prin particularizarea lor. Capitolul cuprinde şi o exprimare matematică, bazată pe analiza de regresie a dependenţei între gradul de asimilare a cunoştinţelor şi numărul de repetări şi exerciţii practice efectuate de elevi.

Al doilea capitol, intitulat „Studii privind particularităţile sportivilor pe baza parametrilor energetici şi de control determinaţi în timpul probei „Miron Georgescu” modificată (MGM)” prezintă rezultatele studiilor realizate cu ajutorul testului MGM, interpretările parametrilor energetici şi de control furnizaţi de acest test, precum şi măsura în care anumiţi factori influenţează valorile parametrilor. Au fost evaluaţi sportivi din diferite ramuri de sport, precum: atleţi, fotbalişti, jucători de tenis. Pentru unii dintre aceştia s-au calculat energiile cinetică, potenţială şi totală şi s-a determinat viteza medie. Analiza de regresie a arătat măsura în care factori somatici, indicii de masă corporală, suprafaţa plantară, presiunea de contact şi densitatea convenţională influenţează valorile parametrilor energetici şi de control. De asemenea, s-a realizat un studiu privind influenţa percepţiei spaţiale asupra parametrilor furnizaţi de testul MGM. În cadrul acestui capitol s-a prezentat şi interfaţa care furnizează instantaneu rezultatele spotivilor testaţi şi mai important, interpretarea acestora.

„Studii privind biomecanica sportului cu ajutorul senzorului Kinect” este titlul celui de-al treilea capitol al primei părţi, în care este prezentat senzorul de mişcare şi echipamentul cu ajutorul căruia s-au realizat analize ale mersului uman normal şi patologic, precum şi analize posturale. Studiile au permis evidenţierea asimetriilor în articulaţii, precum şi deviaţia de la verticală, în cazul analizei posturale.

Capitolul al patrulea, intitulat „Modele virtuale ale membrelor inferioare şi superioare. Studii privind estimarea forţei dezvoltate de muşchi” cuprinde studiile realizate pentru modelarea virtuală a membrelor superioare şi inferioare considerate lanţuri cinematice, precum şi estimarea forţelor musculare, considerate forţe aplicate. Modelul membrelor superioare a fost simulat în timpul execuţiei unei flexii şi în timpul unei flotări, evidenţiindu-se alungirile fibrelor musculare, vitezele de alungire şi acceleraţiile. Pentru evaluarea forţelor musculare s-a folosit modelul Hill şi s-au validat rezultatele prin electromiografie, evidenţiindu-se şi fazele activităţii musculare. Pe baza modelului virtual s-a realizat şi o simulare dinamică, iar studiile au furnizat solicitările din articulaţii.

Al cincilea capitol, intitulat „Proiectarea şi construcţia unui dispozitiv pentru evaluarea lateralităţii” prezintă construcţia şi exploatarea unui sistem mecatronic pentru determinarea şi îmbunătăţirea vitezei de reacţie şi a dominanţei emisferelor cerebrale – numit LateraTEST, în scopul diminuării dezechilibrelor dintre lateralitatea stângă şi lateralitatea dreaptă şi creşterii vitezei de reacţie selective la stimuli vizuali. Sistemul mecatronic este format dintr-o platformă experimentală şi o aplicaţie software care rulează sub Windows, pe un calculator personal (PC) de tip desktop sau notebook. Sistemul mecatronic va fi folosit pentru evaluarea indirectă a lateralităţii, măsurând viteza de reacţie la stimuli vizuali pentru membrul drept şi pentru membrul stâng, folosind mai multe teste cu lumină albă şi lumină colorată. Datele colectate sunt prelucrate de către softul special proiectat, iar rezultatele sunt generate automat sub forma unor rapoarte de stare. Este prezentată şi interfaţa care permite vizualizarea şi printarea rapoartelor de stare la sfârşitul testării.

Capitolul al şaselea are titlul: „Proiectarea şi construcţia unui dispozitiv de monitorizare a deprinderilor specifice atletismului în condiţii reale de manifestare” şi prezintă realizarea practică a ansamblului senzor de presiune - dispozitiv electronic, care are ca utilitate directă achiziţia de date referitoare la studiul mersului şi alergării în atletism şi studierea pasului simplu de alergare pe cele trei faze: faza de amortizare, momentul verticalei şi faza de impulsie precum şi analiza în ceea ce priveşte parametrii energetici şi de control ce influenţează realizarea unor performanţe crescute. Dispozitivul poate fi utilizat în depistarea unor deficienţe în ceea ce priveşte corectitudinea mişcărilor urmărind nesincronizărie dintre piciorul stâng şi cel drept în timpul deplasării (alergării), diferenţele de forţă între acestea, diferenţele de presiune asupra solului, dezechilibrele dintre forţă şi viteză în pregătire şi nu numai. Toate aceste considerente au la bază studiul elementulului esenţial în alergare, veriga principală, reprezentată de acţiunea de impulsie a piciorului pe sol.

Cea de-a doua parte a tezei de abilitare cuprinde direcţiile viitoare de dezvoltare a candidatului, cu cele două coordonate ale dezvoltării personale: activitatea de cercetare şi activitatea academică.

Direcţiile viitoare de cercetare sunt o continuarea celor de până acum, dat fiind faptul că există provocări şi oportunităţi în fiecare dintre direcţiile menţionate.

Abordările noi în educaţie fizică şi sport vor fi preocupări constante, dinamica acestui domeniu determinată de reforma în educaţie, impunând dezvoltarea ştiinţei domeniului, menţinerea statutului Educaţiei fizice ca o componentă importantă a întregului sistem educaţional, lărgirea ariei de cercetare ştiinţifică privind motricitatea umană.

Cercetări extinse vor fi posibile în viitor şi prin dezvoltarea de noi aplicaţii în cazul testului MGM. Acestea vor fi viza diverse sporturi, precum handbalul, badmingtonul, iar posibilitatea de a genera rapoarte de stare care vor cuprinde pe lângă rezultatele testului şi interpretarea acestora va uşura mult activitatea antrenorilor. Aceştia vor elabora programe de pregătire personalizate pentru fiecare sportiv.

Includerea senzorului Kinect în cadrul acestui test va fi un alt obiectiv al cercetărilor viitoare ale candidatului. Rezultatele furnizate de senzor vor sta la baza unor estimări ale solicitărilor din articulaţii în timpul executării săriturilor în plan vertical. Antrenamentele programate vor ţine cont de aceste solicitări şi vor viza creşterea rezistenţei articulaţiilor pentru prevenirea accidentărilor.

Senzorul Kinect şi aplicaţiile special create vor fi folosite pentru analizarea tehnicilor de execuţie din diverse sporturi, evidenţiindu-se greşelile prin analiza cadru cu cadru a înregistrărilor furnizate de senzor. Spre deosebire de o înregistrare video, înregistrările realizate cu ajutorul senzorului kinect sunt vectorizate şi astfel este posibil să se analizeze şi alte caracteristici ale execuţiei precum viteza, acceleraţia, dar şi mărimea solicitărilor din articulaţii, precum şi variaţia cestora în timpul execuţiilor.

Dispozitivul mecatronic pentru evaluarea lateralităţii LateraTEST a fost premiat la Salonul naţional de inventică UGAL-INVENT cu medalia de aur. Realizarea practică a acestuia reprezintă prima etapă din cadrul unor cercetări ample, interdisciplinare.

Lateralitatea se referă la cunoaşterea celor două părţi ale corpului (stânga şi dreapta) şi exprimă inegalitatea funcţională a părţii drepte sau stângi a corpului, ca o consecinţă a diferenţei în dezvoltare şi a repartiţiei funcţiilor în emisferele cerebrale. Dominaţia funcţională a unei părţi a corpului asupra celeilalte determină lateralitatea

Sinteza dinamică între schema corporală, coordonarea perceptiv-motrică şi sarcina motrică are un rol important în învăţarea actelor motrice prin antrenament mental. Îmbunătățirea timpului de reacţie neoromusculară, creşterea capacităţii aerobe și anaerobe, dezvoltarea abilităților sportive nu trebuie să fie realizate doar într-un mod care simulează condițiile de joc sau prin mişcări sau exerciţii practicate în situațiile concrete, ci şi utilizând simulatoare de înaltă performanţă.

LateraTEST reprezintă un echipament special conceput pentru a îmbunătăți timpul de reacție mână-ochi, de coordonare şi rezistenţă musculară. Se vor elabora programe de antrenament pentru îmbunătăţirea vitezei de reacţie pentru sportivii cu lateralitate dreapta sau stânga, în scopul stimulării celor două emisfere ale scoarţei cerebrale, la copii, dar şi la persoane cu deficienţe neuro-motorii. Acestea programe vor fi individualizate, pe baza rapoartelor de stare şi de progres ale fiecărui sportiv.

Sistemul mecatronic experimental este un sistem inovativ, neexistând astfel de dispozitive pentru determinarea lateralităţii şi îmbunătăţirea vitezei de reacţie pe partea stângă/dreaptă. Sistemul va fi folosit cu succes de către sportivii de performanţă, de către kinetoterapeuţi pentru recuperarea persoanelor care şi-au pierdut temporar mobilitatea membrelor superioare, pentru copii în scopul stimulării celor două emisfere cerebrale, de la vârstă fragedă.

Dispozitivul mecatronic creat va deschide direcţii noi de cercetare în domeniul evaluării lateralităţii, precum şi în studiul proceselor neuronale care determină reacţia la stimuli. Cu ajutorul unui sistem de tip BIOPAC se vor putea determina excitaţiile nervoase la nivelul creierului, dar şi reacţiile musculare comandate de centrii nervoşi din creier. Se vor putea astfel îmbunătăţi performanţele sportivilor, se vor putea ameliora deficienţele uşoare ale persoanelor cu afecţiuni neuro-motorii şi se vor putea forma deprinderi de lateralitate stânga/dreapta pentru copii. O altă direcţie de cercetare presupune şi realizarea unui dispozitiv portabil, cu ajutorul căruia se vor putea face determinări ale lateralităţii şi ale vitezei de reacţie în condiţii reale, cu ajutorul unei aplicaţii software instalate pe o tabletă sau pe un telefon mobil cu android, cu transmiterea wireless a datelor.

O altă direcţie pentru cercetările viitoare va implica dispozitivul de monitorizare a deprinderilor specifice atletismului. Acesta are ca utilitate directă achiziţia de date referitoare pe de o parte la studiul mersului şi alergării în atletism şi studierea pasului simplu de alergare, precum şi analiza parametrilor energetici şi a celor de control ce influenţează realizarea unor performanţe crescute, folosind achiziţionate în condiţii reale de manifestare (de la configuraţia terenului pe care se face alergarea/săritura, până la influenţele factorilor de mediu: temperatură, vânt) care sunt stocate pe cardul de memorie urmând a fi analizate şi interpretate cu mare acurateţe în scopul depistării unor deficienţe în ceea ce priveşte corectitudinea mişcărilor, urmărind nesincronizările dintre piciorul stâng şi cel drept în timpul deplasării (alergării), diferenţele de forţă dintre acestea, diferenţele de presiune asupra solului, dezechilibrul dintre forţă şi viteză în pregătire şi nu numai.

Activitatea academică va fi direcţionată către procesul didactic, către activităţi în interesul şcolii, către activităţi cu studenţii.

SECTION B

Scientific and professional achievements and the evolution and development plans for career development

(B-i) Scientific and professional achievements

INTRODUCTION

Performance is an assessment of how well a task is executed and the success of a training program is largely dependent upon satisfying the performance aims associated with it.

Testing and measurement are the means of collecting information upon which subsequent performance evaluations and decisions are made. The whole measurement/evaluation process is a six stage, involving:

1. Selection of characteristics to be measured;
2. Selection of a suitable method of measuring;
3. Data collection;
4. Data analysis;
5. Decisions making;
6. Implementation.

In constructing tests it is important to make sure that they really measure the factors required to be tested, and are thus objective rather than subjective. In doing so all tests should therefore be specific (designed to assess an athlete's fitness for the activity in question), valid (the degree to which the test actually measures what it claims to measure), reliable (capable of consistent repetition) and objective (produce a consistent result irrespective of the tester).

In conducting tests the following points should be considered:

1. Each test should measure only one factor;
2. The test should not require any technical competence on the part of the athlete (unless it is being used to assess technique);
3. Care should be taken to make sure that the athlete understands exactly what is required of him/her, what is being measured and why;
4. The test procedure should be strictly standardised in terms of administration, organisation and environmental conditions.

The results from tests can be used to predict future performance, indicate weaknesses, measure improvement, enable the coach to assess the success of his training program, place the athlete in appropriate training group, and motivate the athlete.

The test results are influenced by the following factors that might have an impact on the results of a test (test reliability): the ambient temperature, noise level and humidity, the amount of sleep the athlete had prior to testing, the athlete's emotional state, medication the athlete may be taking, the time of day, the test environment - surface (track, grass, road, gym), the athlete's prior test experience, accuracy of measurements (times, distances etc.), the personality, knowledge and skill of the tester, surface on which the test is conducted, environmental conditions - wind, rain, etc.

For the coach and athlete it is important to monitor the program of work, to maintain progression in terms of the volume of work and its intensity. Both coach and athlete must keep their own training records. A training diary can give an enormous amount of information about what has happened in the past and how training has gone in the past. When planning future training cycles, information of this kind is invaluable.

The information to be recorded is measuring the status. This can take the form of a test. If the test is repeated throughout the program, it can then be used as a measure of progress within the training discipline. Such tests are: time trials - speed, speed endurance, endurance, muscular endurance - chins, push-ups, strength maximum - single repetitions, maximum repetitions, explosive strength - power bounding, vertical jump, overhead shot putt, mobility - objective measurements of the range of movement.

Following competition, it is important that the coach and athlete get together as soon as possible in order to evaluate the athlete's performance. Elements to be considered are pre-race preparations, focus and performance plans and achievement of these plans. An evaluation form is useful to help the athlete and coach conduct this review. In order to render tests more reliable and valid it is important to use competent and well trained testers, to use standardised and regularly calibrated equipments.

There are many tests for performance evaluation. The most suitable tests for a sport are presented below (Mackenzie, (2001) Queen's College Step Test [WWW] Available from: http://www.brianmac.co.uk/queens.htm [Accessed 11/11/2015]):

Track & Field - Jumps

Fitness Component	Evaluation Test
Aerobic Endurance	Queens College Step Test
Anaerobic Endurance	Running-based Anaerobic Sprint Test
Agility	Quick Feet test
Balance	Standing Stork Test Blind
Body Composition	Body Fat Percentage
Coordination	Hand Eye coordination
Fitness General	Quadrathon
Flexibility	Sit and Reach test
Psychology	Sport Competition Anxiety Test
Reaction Time	Ruler Drop Test
Strength - Core	Core muscle strength and stability test
Strength - Elastic	Jumps Decathlon
Strength - General	Squats Test
Speed and Power	60 metre speed test

Available from: http://www.brianmac.co.uk/queens.htm

Track & Field - Throws

Fitness Component	Evaluation Test
Aerobic Endurance	Queens College Step Test
Anaerobic Endurance	Running-based Anaerobic Sprint Test
Agility	Quick Feet test
Balance	Standing Stork Test Blind
Body Composition	Body Fat Percentage
Coordination	Hand Eye coordination
Fitness General	Medicine Ball Javelin Quadrathlon
Flexibility	Sit and Reach test
Psychology	Sport Competition Anxiety Test
Reaction Time	Ruler Drop Test

Strength - Core	Core muscle strength and stability test
Strength - Elastic	Standing Long Jump test
Strength - General	Squats Test
Speed and Power	60 metre speed test

Available from: http://www.brianmac.co.uk/queens.htm

Track & Field - Sprints

Fitness Component	Evaluation Test
Aerobic Endurance	Queens College Step Test
Anaerobic Endurance	Running-based Anaerobic Sprint Test
Agility	Quick Feet test
Balance	Standing Stork Test Blind
Body Composition	Body Fat Percentage
Coordination	Hand Eye coordination
Fitness General	Quadrathon
Flexibility	Sit and Reach test
Psychology	Sport Competition Anxiety Test
Reaction Time	Ruler Drop Test
Strength - Core	Core muscle strength and stability test
Strength - Elastic	Standing Long Jump test
Strength - General	Squats Test
Speed and Power	60 metre speed test

Available from: http://www.brianmac.co.uk/queens.htm

Running - Endurance

Fitness Component	Evaluation Test
Aerobic Endurance	Cooper VO_2 max test
Anaerobic Endurance	Running-based Anaerobic Sprint Test
Agility	Quick Feet test
Balance	Standing Stork Test Blind
Body Composition	Body Fat Percentage
Coordination	Hand Eye coordination
Fitness General	Quadrathon
Flexibility	Sit and Reach test
Psychology	Sport Competition Anxiety Test
Reaction Time	Ruler Drop Test
Strength - Core	Core muscle strength and stability test
Strength - Elastic	Standing Long Jump test
Strength - General	Squats Test
Speed and Power	60 metre speed test

Available from: http://www.brianmac.co.uk/queens.htm

Soccer

Fitness Component	Evaluation Test
Aerobic Endurance	Yo-Yo Intermittent Endurance Test
Anaerobic Endurance	Running-based Anaerobic Sprint Test

Agility	Illinois agility run test
Balance	Standing Stork Test Blind
Body Composition	Body Fat Percentage
Coordination	Hand Eye coordination
Fitness General	Wilf Paish Rugby Football Tests
Flexibility	Sit and Reach test
Psychology	Sport Competition Anxiety Test
Reaction Time	Ruler Drop Test
Strength - Core	Core muscle strength and stability test
Strength - Elastic	Standing Long Jump test
Strength - General	Burpee Test
Speed and Power	40 metre multiple Sprint Test

Available from: http://www.brianmac.co.uk/queens.htm

The author's objective is to develop new and feasible tests for assessing the human performance. In order to know, explain and improve the preparation of athletes it is important to conduct a permanent and systematic assessment of skills and motor performance.

The evaluation is performed using specific knowledge of motor characteristics, using information that once quantitatively and qualitatively processed can provide the basis for future improvements, by reference to criteria and scales and best practices. No less important are trends in athlete development that can predict time series based on systematic evaluation.

By measuring and assessing the performance of athletes the current preparation status is assessed, the causes that have led to an inadequate level of performance are revealed and concrete solutions to improvement are shaped.

These are the objective of the author's future research themes.

About the author

The author has obtained the PhD degree with the doctoral dissertation entitled "The efficiency of using audio-visual means in physical education class in secondary school" in 2008, at the State University of Physical Education and Sport, in Chisinau, Moldova.

One of the general objectives of the thesis was to determine the effectiveness of physical education class by applying audio visual means and experimental argumentation of the appropriateness of using audio visual means in physical education class for secondary school students. The results of the thesis have been the subject of many national and international scientific conferences reports as well as the subject of many scientific papers in BDI journals.

The innovations and original contributions of the thesis were the variety of audio-visual means used in physical education class at different moments and their contribution to the accumulation of basic motor skills and applicative tools to strengthening health, body hardening, the psycho-physical balance of students, but particularly to improve basic motor skills indices. Restructuring the content of physical education class is the starting point of modernization of teaching. In this respect the results of this research have confirmed the usefulness of new and modern media, acting on long term, which are always open for improvement and enhancements.

After obtaining the doctorate, the author considered that it is time to define his research directions and to orient his energy and ideas towards realistic and feasible objectives, in order to prove his maturity as a researcher.

Thus, six research directions have outlined, as follows:

1. Following the research directions defined in the context of the PhD these, the author's researches aim at studying the efficiency of audio-visual mean in physical education classes, toghether with neuro-motor and sensorial-perceptual skills improvement. Also, some new approaches related to physical education and sports management;
2. Investigation of the athletes' peculiarities using tests that reveal the energetic characteristics and the control ones, like MGM (Miron Georgescu modified) test;
3. Biomechanical study oriented trough objectives such as human body performance, rehabilitation and pathologies using the kinect sensors;
4. Modeling the upper and lower limbs and assessing the magnitude of muscle forces;
5. Designing and building a mechatronic system for determining and improving the reaction rate and the dominance of cerebral hemispheres – named LateraTEST, in order to reduce imbalances between left and right laterality and increase the selective reaction rate to visual stimuli.
6. Designing and building a device for monitoring the athletic skills in real conditions.

CHAPTER 1

The efficiency of audio-visual mean in physical education classes. Improvement of neuro-motor and sensorial-perceptual skills. New approaches related to physical education and sports management.

The first coordinate of the author's research following his PhD thesis is related to physical education and sports. Thus, some papers have continued his research regarding the influence of audio-visual means on physical education classes (Mereuta, Mereuta, 2013, Mereuta, Ciorba, 2008).

Considered to be unconventional, the audio-visual means were original grouped, and some recommendation regarding their use in different lessons types such as: games, athletics and gymnastics were stated. Specialists in physical education and sport should be directed towards finding new means which will increase the effectiveness of physical education lessons, together with the education of students in the spirit of the effective and affective participation during classes.

Also, the human body adjustment to effort during unconventional physical education classes was studied (Mereuta, 2009). The most relevant functional indices, such as: heart rate, respiratory frequency, Ruffier's test, vegetative sample and vital capacity were analyzed, while the unconventional methods as audio-visual means were used during all the phases of a physical education class.

In order to evaluate the influence of audio-visual means, an experiment was conducted, using children from fifth grade, from two distinct classes.

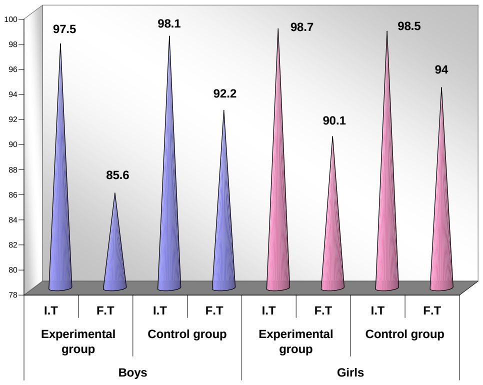
For the first group, named the control group, consisting of 29 students (15 girls and 14 boys), standard methods and procedures for teaching physical education were used.

The second group, named the experimental group, consisting of 17 girls and 15 boys, was subjected to an experiment, consisting of using audio-visual means during the whole moments of a lesson, such as:

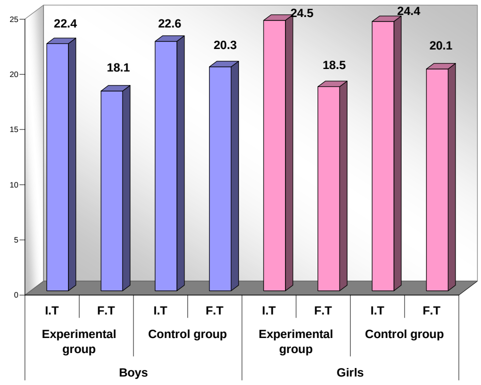
a) during the adaptation lesson, the audio-visual means have been used, around 20% of the preparation time and 20% of the closing time;
b) during the learning period, the audio-visual means were used about 30-40% at the beginning, then the percentage decreased up to 10-20% to the end;
c) during the improvement lesson, the audio-visual means were used within 30% to 50% of the entire period.

The students were filmed during the lessons and we ran the movies for them, in order to be aware of their mistakes and to do something to reduce them and to get better results.

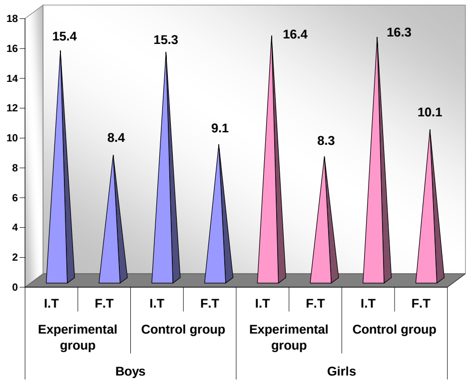
In order to evaluate the influence of audio-visual means upon the functional indexes, we have determined the values of indexes at starting point for both groups and the values after the pedagogical experiment. The significance rate was determined using T-test.



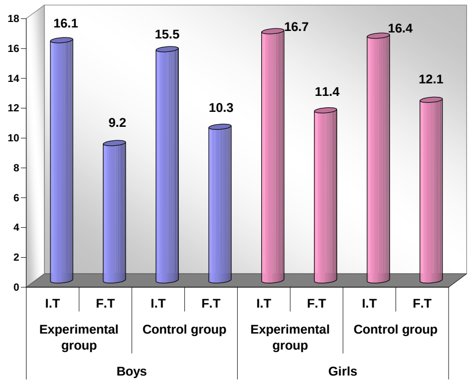
a) Heart rate index



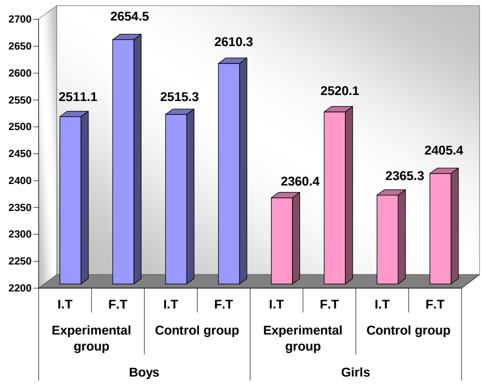
b) Respiratory frequency index



c) Ruffier's test



d) The vegetative sample



e) The vital capacity

Fig. 1.1 Functional indexes

The final testing recorded significant differences in functional indexes measured for the control and the experimental groups, indicating that systematic factors (audio-visual means) have led to a better adjustment of the human body during physical exercise (fig.1.1). Analyzing the results of functional tests, we can state that the parameters for adjusting the body to support the effort are modeled in the training process and a systematic activity consisting of implementing audio-visual tools, can improve the effort. For all functional indicators, the results are superior in experimental group over the control group, as a result of the unconventional method used.

Another study has presented a method for increasing the students' capacity of reception and acquiring information using audiovisual media in gymnasium, i.e. psychomotor stimulation of students using audiovisual media (Mereuta, Mereuta, 2013). The opportunity of this new approach has been proved using a questionnaire which has revealed the fact that more than 50% of the interviewees agree the idea of using audiovisual media in physical education lesson. The average score for the experimental group assessed by experts to athletics testing has increased by 226%, while the gym test has proved a rise of the average score by 208%. Results of equal importance and significant have been achieved also by handball test.

Training students and maintaining interest towards physical exercise are the main tasks of physical education teacher. To perform, the teacher must act in full agreement with the desire and physical training of children and students, as a result of their physiological development (Bejat, 1971, Tucicov-Bogdan, 1977, Samova, 1982, Mudric, 1986, Gujalovschi, 1986, Marolicaru, 1987, Ciorbă, 1987, 1991, Epuran, 1988, Ghibu, 1988, Gârleanu, 1989, Crilov, 1990).

In order to achieve these objectives it is important to permanently correlate the tasks of educational process (Samova, 1982, Mudric, 1986, Marolicaru, 1987, Ciorbă, 1987, 1991, Ghebu, 1988, Gârleanu, 1989, Sava, S. Bicherschi, Grimalschi, 2000, 2001).

It is necessary that the educational process is optimized using audiovisual media during physical education classes. (Cristea, Vollrath, 1968, Creţu, 1972, Gage, Briggs, 1977, Guţu, Pîsîaru, 1999, Morărescu, Morărescu, Peterfy, Bendorfeanu, 1969).

One of the major objectives of the educational process is stimulating and guiding the formative process of secondary school pupils' interest to use audiovisual media (Zaşimovschi, 1979, Golu, 1985, Ilin, 1987, Ciorbă, Ghimpu, 1991, Bunescu, 1992, Crişan, Guţu, 1996, Badiu, 1997, Cârstea, 1999, Bieherschi, Sava, Grimalschi, 2000, Ciorbă, 2001). In order to achieve these goals, new methods should be chosen, modern ones that combined with the appropriate traditional approaches will allow upgrading and improving the educational process.

The teaching process, in general and the knowledge transmission during physical education class, in particular, are strongly influenced by audio-visual information that plays an important role. Naturally, some of the audio-visual information that will be discussed below can be folded on other disciplines, but they find their true value in physical education teaching process, where the stimulus-response relationship acquires new meanings (Armstrong, 1973, Astolfi, 1997; Crinone, Gautellier, 1997, Dave, 1991, Renard, 1965).

This study has proved that using audiovisual media in physical education class the neuro-motor and sensorial-perceptual skills were improved, thus ensuring the development of abilities and motor skills.

The average score for the experimental group assessed by experts to athletics testing has increased from 2.62±0.161 to 8.56±0.146 ($p<0.001$), proving a significant progress. The gym test has proved also an improvement of the results, the average score rising from 2.67±0.15 to 8.25±0.16 ($p<0.001$). Results of equal importance and significant have been achieved at handball test. The average score for the experimental group assessed by experts has increased from 2.79±0.13 to 8.23±0.13 ($p<0.001$), proving also a significant progress.

The study has revealed the increase of students' motor skills from both experimental and control group. They have started from the same level of physical preparation, but better outcomes have been recorded by the experimental group, proving that applying audiovisual media during physical education classes is the significant factor influencing the performance enhancing.

Another study (Mereuta, Mereuta, 2013) has highlighted new features in planning and organizing the educational process in physical education class based on the theory of "operational calculus" and on the theory of "games". The operational calculus is related to the accuracy level of predicting the results of every action, i.e. in physical education class (Armstrong, Henson, Savage, 1993) it is important to know that when choosing an action from several possibilities, the following four situations can arise:

a) each action leads to a well-known result (determining conditions);
b) each action can lead, in different circumstances, to different results, but the probability of appearance is known (risk conditions);
c) each action can lead, in different circumstances, to different results, but the probability of appearance is unknown (undermining conditions);
d) each action can lead to a certain result or to several possible results (determining or risk conditions).

If the teacher chooses actions with determined results, the planning model is developed using the linear programming technique (fig.1.2).

The theory of games is the solution for modeling the planning activity, when the teacher chooses actions with risk conditions, meaning that he chooses a teaching technique which will provide different results when applied on different students.

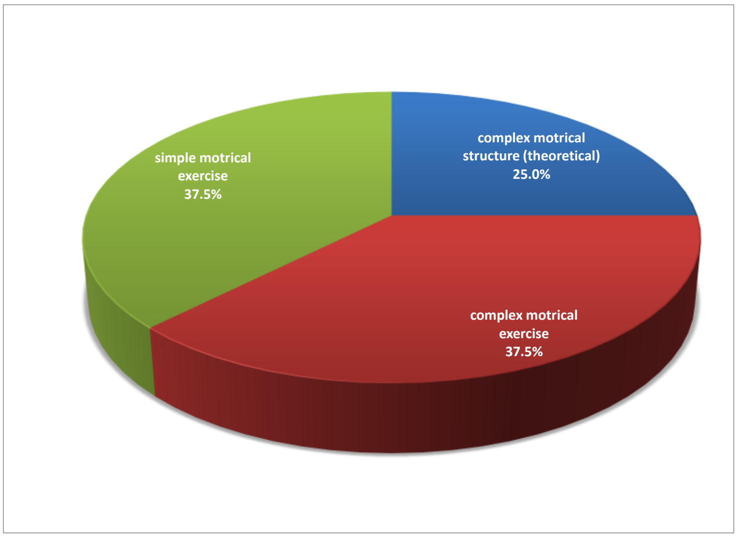


Fig.1.2 Optimum solution for maximum development of motrical memory and skills

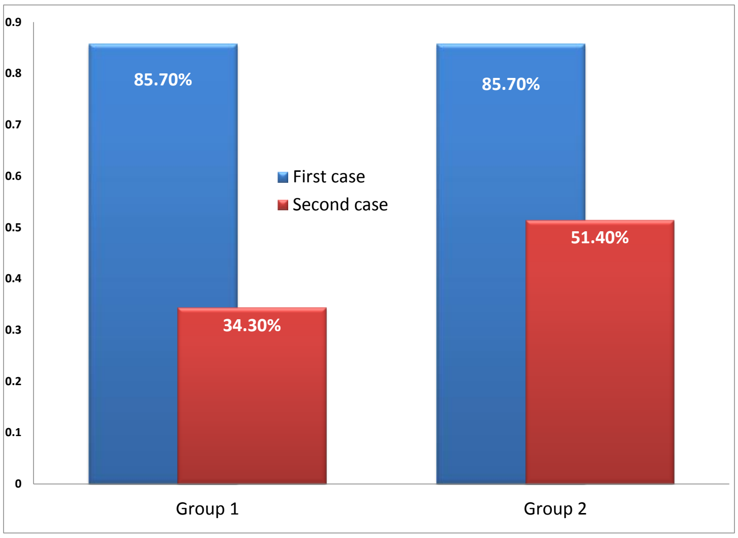


Fig.1.3 The teacher's gains using the same optimum strategy

The proposed models are applicable to simple situations in teaching process, but as any abstract scheme they cannot reveal the reality. The gain of that activity consists of indicating to the specialist the basics of planning activities, which is strongly related to the practical experience, to the actual individuality (fig.1.3).

A new approach regarding the management in sports that is based on the principles of reengineering was also a research team (Mereuta, Mereuta, 2009). Applying that modern and pure management system, called reengineering in sports activity, the author hope to get better and better results, in order to increase both the health state and the performances of trained athletes.

The similarities between BPR (Business Process Reengineering) and Sports Managements, as well as a solution for a proper implementation of such model of management were presented, together with the five components of the basic BPR model and their features for Sports Management.

The answers to some fundamental questions might prove that the traditional way of thinking is overcome and important changes must be reinvented (fig. 1.4). Sports management must also find the answers for these questions and for much more that will arise.

Fig. 1.4 Fundamental questions

Eight common problems for reengineering can be also revealed in sports management (fig.1.5):

a) Combined specializations. In sports management all trainers have to be prepared not only in their sports field, but also in some related fields, such as: physical development, psychology, pedagogy, nutrition, health and management. As result, the athletes will be aware of all the consequences of their activity and they will be able to perform better and better.

b) Everyone is a decision factor. The decisions are no longer the privilege of top management, because everyone can make a statement regarding his activity and can make decisions of his own. Thus, the team should work as one, involving in its activity all factors related to the program, all their opinions and all the tasks that need to be fulfilled.

c) Less control activities. Business Process Reengineering reduces the control activities, if the management programs are well organized and scientifically based. Thus, some forms of control can disappear: the simultaneous control, the direct control and the compliance one. It would remain the anterior control, which would estimate the input parameters of sports activity, mostly on training, the subsequent control, which will provide assessments on the progress of athletes, and the collateral control, which is now transformed into a periodical appreciation of all the aspects regarding the training activity. The self-control must not be neglected; it really should prevail in sports activities, as one of the most important control types

d) The domination of centralized/non centralized hybrid activities. Top management, the leader support and the decision of all members of the team are some factors that determine the centralization of all decisions. All the trainers, athletes are responsible for their decisions and activities, proving that the Business Process Reengineering has non centralized hybrid operations.

e) Multiple versions of the process. The decision process and the management process don’t have a unique form, for each sports field there are particular decisions and processes and the trainers and athletes have to act accordingly. The same organization can be proficient in many sports field, which are not connected and which require different approaches.

f) Business Process Reengineering is useful when it proves to be rational. If we consider a small sportive organization, reengineering is not a proper solution for management, as it might be not so opportune. When we are dealing with bigger organizations, it is necessary to rethink the sports management, in order to render it more and more useful and rational.

g) The project manager is the essence of connections. The coordinator must ensure a free way of thinking, to move the management into the desired direction, to ensure a proper link between the members of the team, the trainers, the athletes and other administrative staff involved in sports processes. He is the central point of all connections, thus he has to prove leadership abilities, communications and teamwork skills.

h) Natural connections of the phases of process. All the sports field of an organization must be equally developed, taking into account a natural sequence of these fields. We cannot develop a team sport activity, if we don't have a proper physical development, which requires running, weight lifting etc.

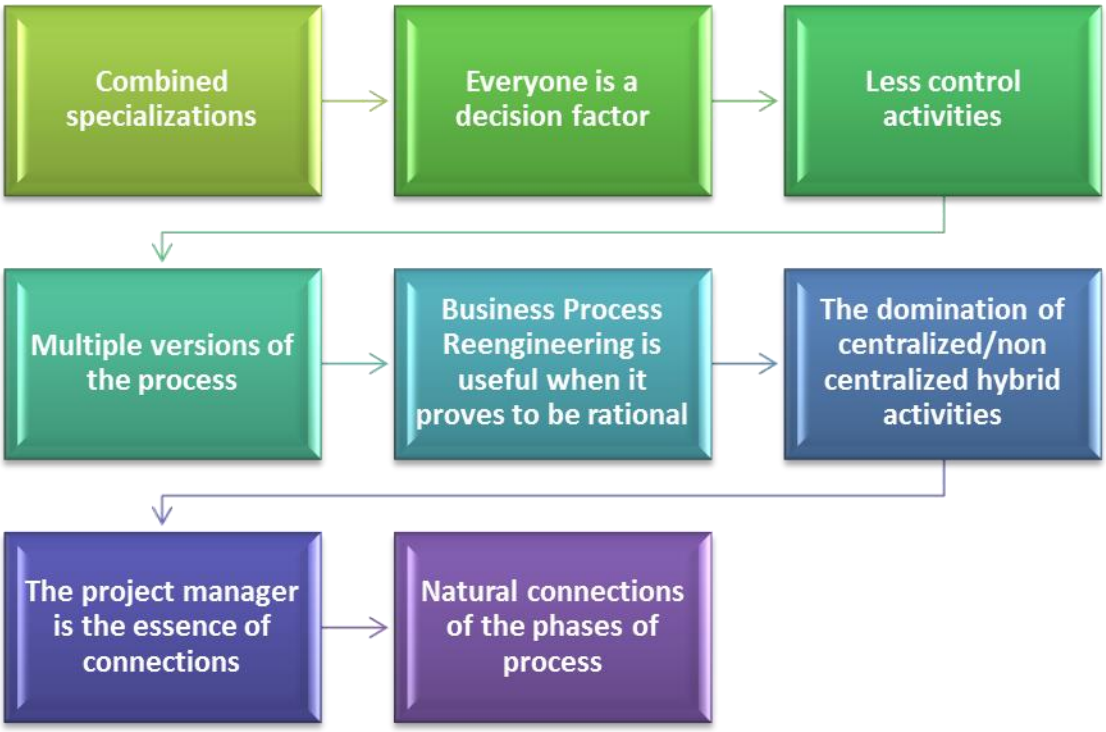


Fig.1.5 – Common problems for business process reengineering

The evolution of sports management reveals the necessity of a radical change in organizing that activity Business Process Reengineering is a general management process, which can be successfully used in sports management. We can use all the reengineering concepts to develop a new way of managing the sports activity.

Another study was foused on a method for establishing a qualitative expression of the dependency of acquiring new knowledge by students having different levels of memory development and the number of repeated and applied exercises (Mereuta, Mereuta 2013). Thus, we have tried to express the form, the conditions and the objective connections that occur between teaching outcomes and two influence factors: the memory and the number of applied exercises. The influence of memory efficiency is significant ($p<0.01$).

The mathematical model links the students'grades, the productivity of memory and the number of repetitions. The model of the pedagogical phenomena is:

$$z = a + bx + cy \quad (1.1)$$

where: z denotes the students' grades;
x is the productivity of memory;
y is the number of repetitions.

The coefficients are determined using the least square method,

$$z = 1.23 + 3.14x + 0.44y \quad (1.2)$$

The significance test has revealed an accuracy up to 99% ($p<0.01$), meaning that the number of repetitions is significantly influencing the students' performances.

All the differences between groups are not related to the random variability of grades.

Another study (Cicma, Mereuta, 2013) has presented the importance of psychological training in increasing the performance in handball, namely the relaxation, which is a psychotherapeutical and self formative technique scientifically based, aiming to achieve a muscular and nervous relieving, and to save the mental energy, in order to determine the increasing the body resistance to stress, or diminishing of the stress effects. Finally, the performance of the participants in the experiment increased from 45.45% to 72.7%, during two competitional years.

Another study (Cicma, Mereuta, 2013) can be considered as an image of motivational components during education through sports, thus providing the opportunity to choose the most efficient ways of accomplishing this form of education (fig. 1.6).

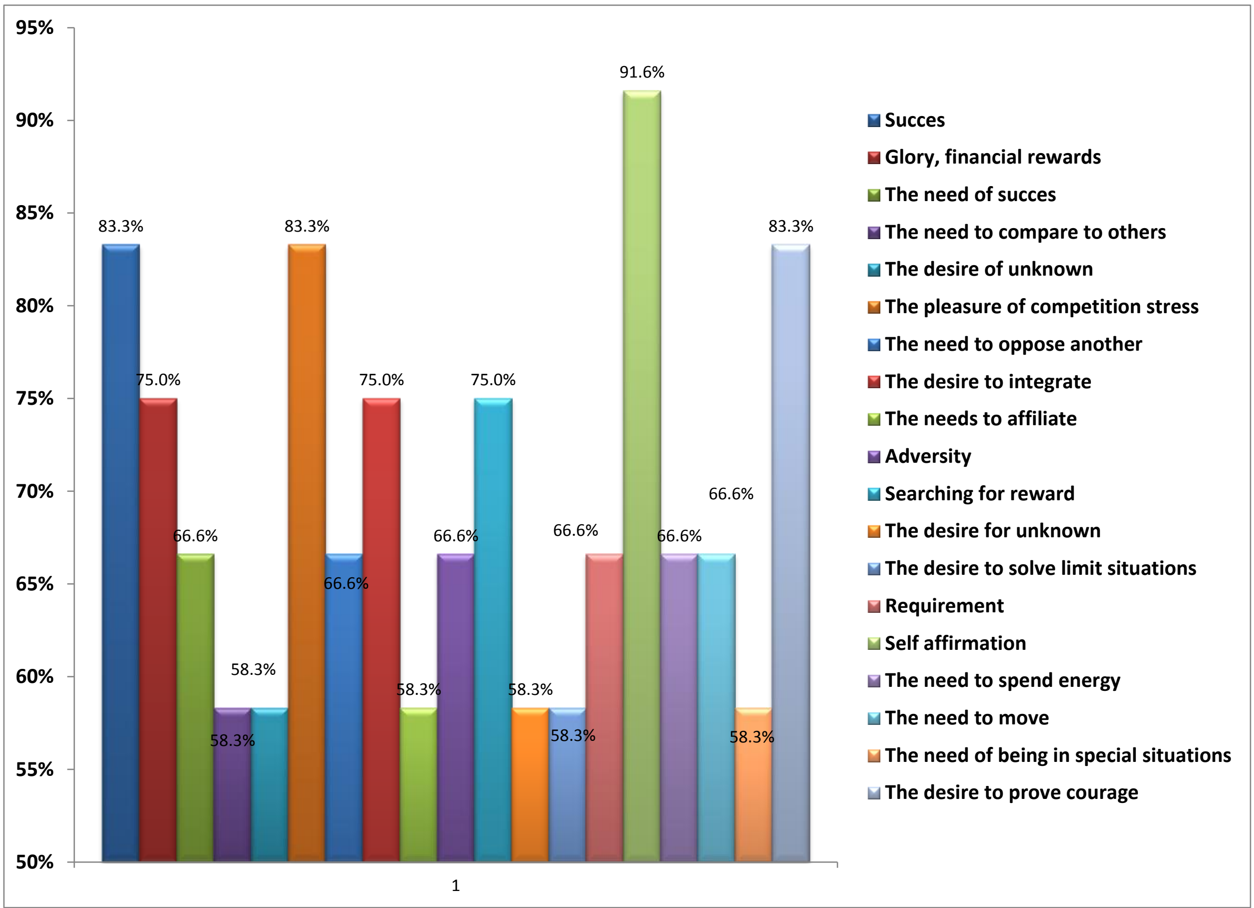


Fig. 1.6 The components of motivation

Other studies have focused on the efficiency of different means used during the training stages of gymnasts (Talaghir, Mereuta et.al. 2011), football players (manolache, Talaghir, Mereuta et al. 2001), and handball players (Cicma, Mereuta 2011), but also the development of students' motric qualities during physical education classes (Cicma, Mereuta, 2011, 2012, Mereuta, 2008).

CHAPTER 2

Investigation of the athletes' peculiarities using MGM test for energetic and the control parameters

Theoretical and practical knowledge in the field of athletic training and a high quality of competitions, require performing scientific training and finding solutions to all the problems detected when the athletes are tested.

The solutions must be carefully chosen, taking into account the requirements, the principles and the scientific methods regarding the training process, the physiology, the biomechanics, the biochemistry, the hygiene, the pedagogy and the athletes' psychology.

The quality of training must be appraised regarding the following issues:

a) The continuity of the training process and the continuity of joining to competitions;
b) The dynamics of effort during the training process and during competitions;
c) The volume of training, referring also to both training period and competitions;
d) The intensity during the training process and competitions;
e) The athletes' specialization;
f) The interrelation between all the factors involved in the training process;
g) The importance of physical training;
h) The psychological preparation;
i) The individualization of training according to the athletes' peculiarities;

The training process must be planned attending to:

a) Ensure an equilibrium between the training process and the testing and official competitions;
b) Establishing and keeping the methods and the contents of training before, during and after competition periods;
c) Choosing the most efficient means for training;
d) Developing the individual abilities;
e) Considering the complex aspects of warming up, regarding the technical, physiological and psychological effects of that important state in the training process;
f) Rational use of time during training;
g) Achievement of tests trails and controls trails.

The importance of testing and investigating in sports is revealed by the following:

a) The objective results of testing procedures are useful to trainers and technicians for a proper characterization of the athlete performing in a certain branch of sport;
b) The trainers can establish if the training process was well conducted comparing the results of the tests in two moments: before and after the training period;

c) Every component that competes to achieve performance should be individualized and treated properly;
d) Specifying the sources and causes that negatively affect performance, in order to detect them in an early stage and correct them.
e) To achieve these objectives, an investigation and testing procedure must fulfill the following requirements:
f) To be appropriate to the goal;
g) To use methods and techniques specific for the competition, training and laboratory stages;
h) To be time effective;
i) To provide immediate, simple and accurate information to trainers.

2.1. The MGM testing procedure

Investigating the athletes' peculiarities is often performed using tests that reveal both the basic motrical characteristics and the control ones (force, velocity and endurance).

The testing procedure called MGM begins with determining the anaerobe capacity of effort which allows rendition of basic elements of neuro-motrical qualities, energetical and control qualities during a force-velocity effort (MGM test description).

The MGM test highlights the athletes' energy when a series of jumps is performed. The interpretation of results takes into account the viscosity and elasticity of muscular tissue. The effort in this test is characteristic to large groups of muscles and the lower limb can provide such information, as their effort is influencing the results.

Thus we can highlight the energetical athletes' resources when they perform jumps on both legs and on one leg, we can highlight the athletes' basic qualities and the information provided by MGM tests are very general and useful for all next training periods.

As the effort of the lower limbs is the same in all sports, the results of MGM test are not misstated by athletes' previous abilities, due to the fact that this is an unspecific effort.

During this test, the athletes are performing 3 series of 15 jumps, on both legs, on the right leg and, finally on the left leg. A pause of 30 seconds to 1 minute is required, between the 3 series of jumps.

All the jumps are performed on a rectangular carpet (1m x 1.2 m) connected to a data acquisition board. The variable measured is the time spent on air and on ground for each jump; with millisecond order accuracy of measurements (MGM test description).

After the automatic filtering of results, the computer provides only 10 valid jumps which are the starting point of all rating for the energetical and control parameters (table 2.1).

Table 2.1 Energetic and control parameters

Energetical parameters		
Average Unit Power AUP	**Average Flying Height AFH**	**Repetition Rate RR**

$AUP = \dfrac{\frac{g}{8}\cdot\sum_{i=1}^{10} Ta_i^{\,2}}{\sum_{i=1}^{10}(Ta_i + Ts_i)}$	$AFH = \dfrac{\frac{g}{8}\cdot\sum_{i=1}^{10} Ta_i^{\,2}}{10}$	$RR = \dfrac{\sum_{i=1}^{10} Ts_i}{10}$

Control parameters	
Energetical variability coefficient (CVE)	**Structural variability coefficient (CVS)**
$CVE = \dfrac{StDev(Ta_i)}{\frac{\sum_{i=1}^{10} Ta_i}{10}}\cdot 100$	$CVS = \dfrac{StDev(Ts_i)}{\frac{\sum_{i=1}^{10} Ts_i}{10}}\cdot 100$

Ta_i - flying time for the jump "i", Ts_i - contact ground time for the jump "i"

2.2. MGM test results

The level of training is assessed using the energetic parameters, like unit power, average flying height and repetition rate. They are relevant for the specificity for each individual, characterizing the force velocity ratio. For a trainer is very important be aware of the energetic parameters of athletes. The trainer will be able to focus in the direction of reducing the energy asymmetries and improving force-velocity ratio, as characteristic of physical training (Mereuta, Mereuta, 2012)

The energetical parameters were determined for fifteen male athletes (fig.2.1). The best power unit energetic parameter was 26,6% higher than the group average for participant 13 (P13), while P3 records a value 24.4% lower than the average. The best average flying height was 38.5% higher than the average group for P13 and P11, while P4 recorded a 39.1% lower value. The repetition rate was 10% higher than the average for P12 and P15, but the smallest values of this energetic parameters were 10% lower than the average for P4, P11 and P13.

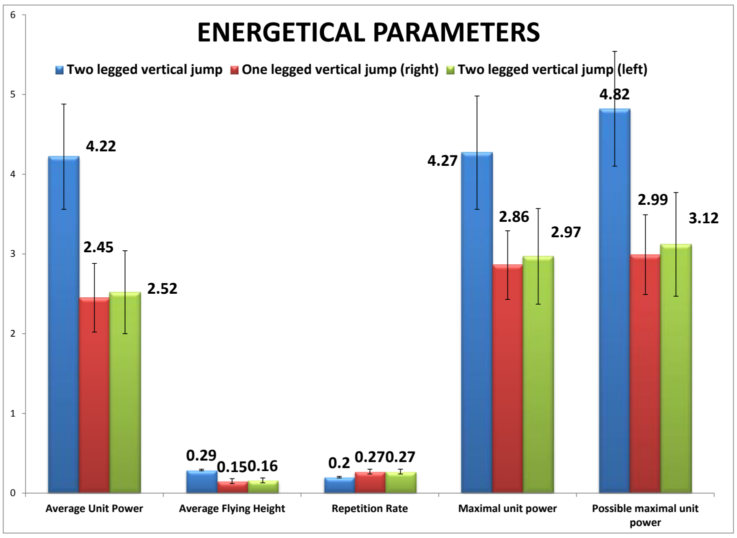
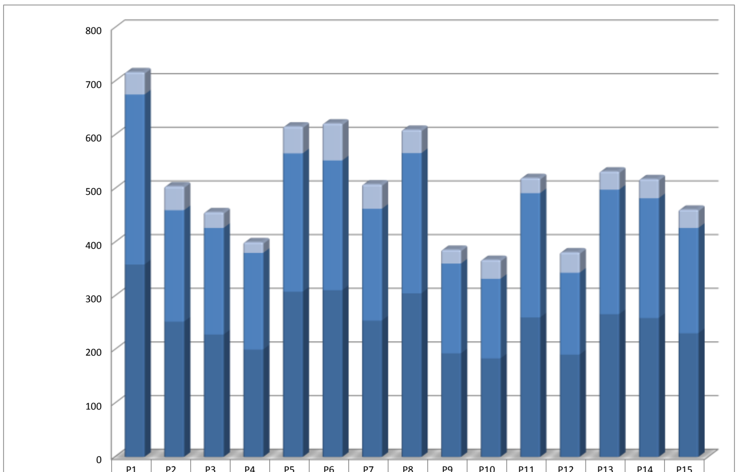


Fig.2.1. Average energetical parameters

The same quantitative approach can be emphasized for the energetic parameters while performing one-legged vertical jump.

Based on the energetic parameters provided by MGM test, we were able now to estimate the medium velocity for each participant in the test. Thus, considering that total energy is the sum of kinetic and potential energy, and at the maximum vertical height the energy is only potential (fig.2.2), we get the average velocity:

$$\left.\begin{aligned} E_t &= mgh_{\max} \\ E_t &= mgh + \frac{mv^2}{2} \end{aligned}\right\} \Rightarrow v = \sqrt{2g \cdot (h_{\max} - h)} \qquad (2.1)$$



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Kinetic energy	41.69	44.5	29.43	20.01	50.13	69.06	45.6	43.56	25.74	35.32	28.25	38.14	33.96	35.71	34.14
Potential energy	316.86	207.66	198.65	180.11	257.81	241.72	208.44	261.34	167.32	148.33	231.67	152.57	232.08	223.18	196.3
Total energy	358.56	252.16	228.08	200.12	307.94	310.78	254.04	304.89	193.06	183.64	259.93	190.71	266.04	258.89	230.44

Fig. 2.2 Kinetic, potential and total energy

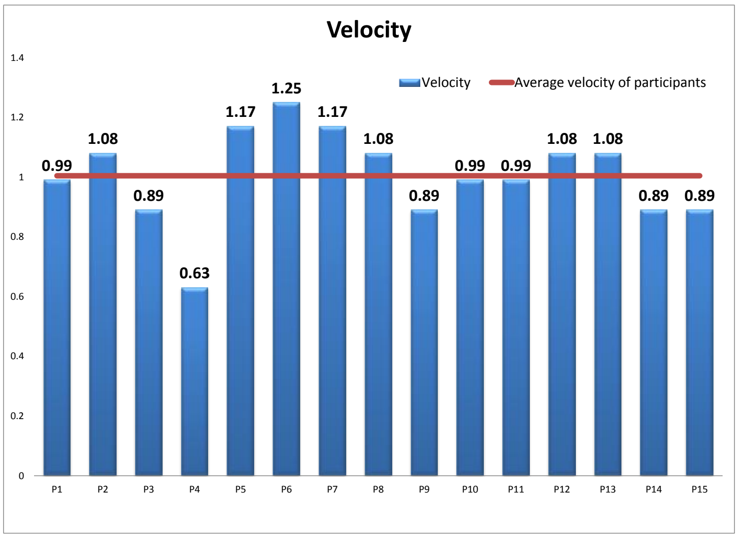


Fig.2. 3 Average velocity

Comparing the medium velocity of each participant in the test to the mean of the group, we found that the velocity is 24.6% higher than the average for P6, but the smallest values of the velocity parameters are 11.8% lower than the average for P3, P9, P14 and P15 (fig. 2.3).

The output data revealed the control parameters for each participant in the test, meaning that we were able to get the energetic variation coefficient (CVE) and structural variation coefficient (CVS). The energetic variation coefficient (CVE) refers to the ability to control energy in unspecific motion and brings data on the quality of detachment on vault. The control parameter also highlights the automation of motion that is desired to be maximized for sports that require precise identical motions (canoeing, gymnastics, skating) and which is not intended to be maximal, but optimum, for sports involving an opponent (fencing, games, boxing). A higher numerical value of CVE highlights a weak control of the athlete at the completion phases.

The structural variation coefficient (CVS) refers to the ability to control the ground contact preparation phase, to resume the ground contact when jumping, to defense, to prepare and catch the object while launching. The average on two-legged vertical jump is 3 - 3.5, meaning that at higher values the athlete does not anticipate, does not prepare, is not ready to catch, is too rigid, and drops objects. A smaller value for CVS highlights the fact that the athlete is not aware of its body structure and he does not know how to prepare for a contact (with the opponent, with a ball or with the ground). The results render the possibility to estimate the neuromuscular activity of each athlete, and discuss their control over the energetic resources and their ability to control the motion phases, by comparing their control parameters to the mean of the group (fig.2.4) or to the recommended values from literature (Bosco et al, 1983, Mereuta, et al. 2010).

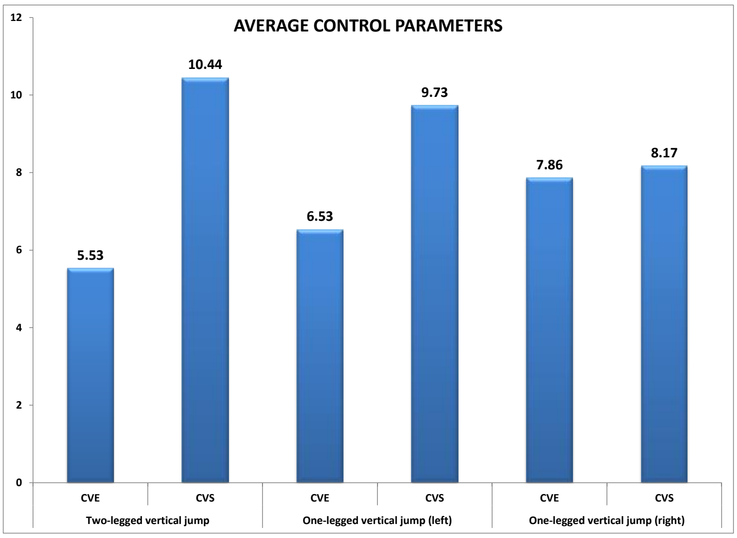


Fig.2.4. Average control parameters

All the participants in the test have proved that their capacity of control is weak and sometimes very weak (P5 while jumping on left leg, P9 while jumping on right leg and P8 while jumping on both legs) (fig. 2. 4). We can conclude that for values of CVS < 3 (stated in literature [9]) the athlete is not able to prepare the contact, whatever its nature is, with the opponent, with the ball, with ground. Also, for values of CVS > 3.5, we conclude that the athlete is rigid, he is not able to anticipate next phase and often he reacts with delay.

The influence of anthropometric parameters on the control parameters CVE and CVS was determined using the regression analysis (Mereuta, Mereuta, 2012).

The regression method provides the estimation of a linear model using the least squares method and the calculus of the statistics associated to this model. Considering as dependent variable the CVE control parameter, we find that only 14.42% of the variance of CVE on two-legged vertical jump is influenced by the variance of the height, mass and foot length. The estimated values for the coefficient of the model are tested for significance. The results show that the intercept (constant term of the model) is -6.75302, while the estimated coefficients are 0.014, -0.04621 and 0.306.

The proposed models for control parameters are:

$$CVE_{TLVJ} = -6.75302 + 0.014 \cdot H - 0.04621 \cdot M + 0.306 \cdot L_f \quad (2.2)$$

$$CVE_{RLVJ} = -8.046 - 0.244 \cdot H + 0.108 \cdot M + 1.176 \cdot L_f \quad (2.3)$$

$$CVE_{LLVJ} = -13.284 + 0.002 \cdot H + 0.026 \cdot M + 0.436 \cdot L_f \quad (2.4)$$

$$CVS_{TLVJ} = -30.47 + 0.04 \cdot H - 0.13 \cdot M + 1.03 \cdot L_f \quad (2.5)$$

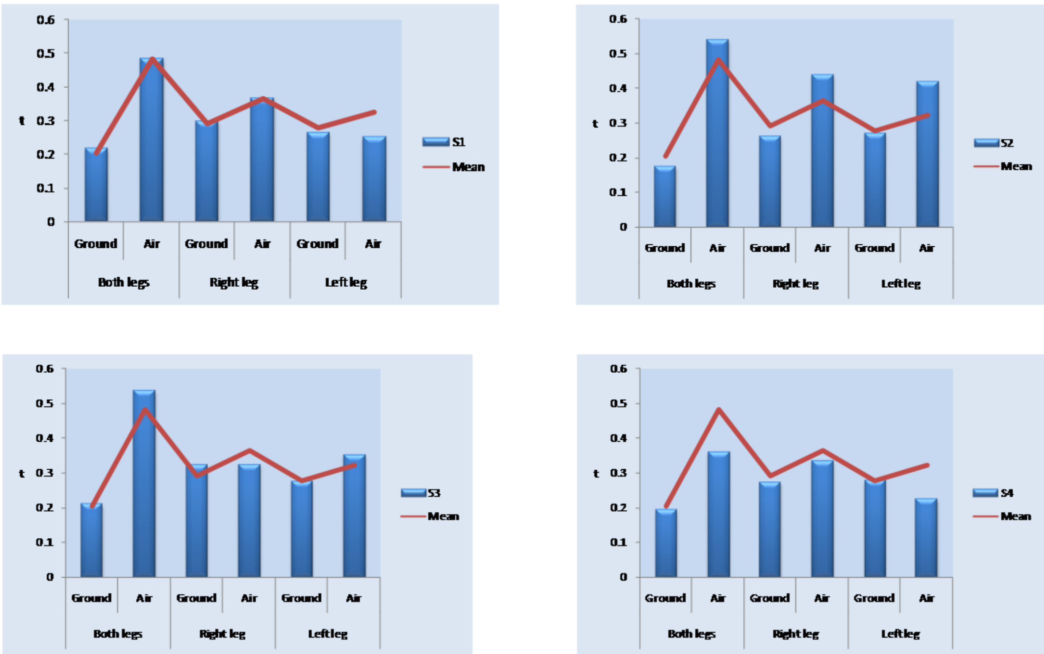
$$CVS_{RLVJ} = -9.044 + 0.176 \cdot H + 0.027 \cdot M + 1.125 \cdot L_f \quad (2.6)$$

$$CVS_{LLVJ} = -12.057 + 0.288 \cdot H - 0.11 \cdot M + 0.521 \cdot L_f \quad (2.7)$$

Where H is the height, M is the body mass, Lf is the foot length

The regression analysis reveals the fact that the most significant influence of anthropometric data on CVS control parameters occurs for the two-legged vertical jump, meaning that 42% of the total variance is produced by the independent variables. As for CVS determined during one-legged vertical jumps, only 0.08% of the total variance is determined by anthropometric data, for the right leg and only 11.93% for the left leg.

The author has compared the energetic and control parameters for each athlete and the mean of the group (fig.2.5). The mean of the group is depicted in red and we can see the differences of each athlete from the mean, for the periods of time spent on the ground and on the flying phase, during the jump.



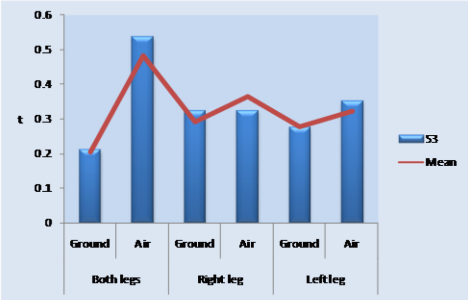


Fig.2.5 Comparison between the mean of the group and the athletes' parameters

For the first athlete the control parameters are close to the mean of the group, only for the jump on his left leg. In this case we can see a difference of 21.8% from the mean of the group. For the second athlete, the situation is more complicated, as his parameters are very different from those of the group. Thus, for the jump on two legs there is a difference of 12.1% for the time on air, a difference of 20.2% for the jump on the right leg on air and 29.3% for the jump on the left leg on air. Another important difference is related to the time on the ground on the jump on two legs, which is smaller by 14.2% than the mean of the group.

For the third athlete the differences are 11% smaller for the time on air at the jump on two legs and for the jump on the right leg on the ground. As for the jump on the right leg, we can observe that the time on the ground in smaller than the mean of the group by 11%.

The fourth athlete has notable differences from the mean of the group, such as a smaller time on air for the jump on both legs by 25.5% than the mean of the group, while the time on air for the jump on the left leg is smaller than the mean by 30.1%.

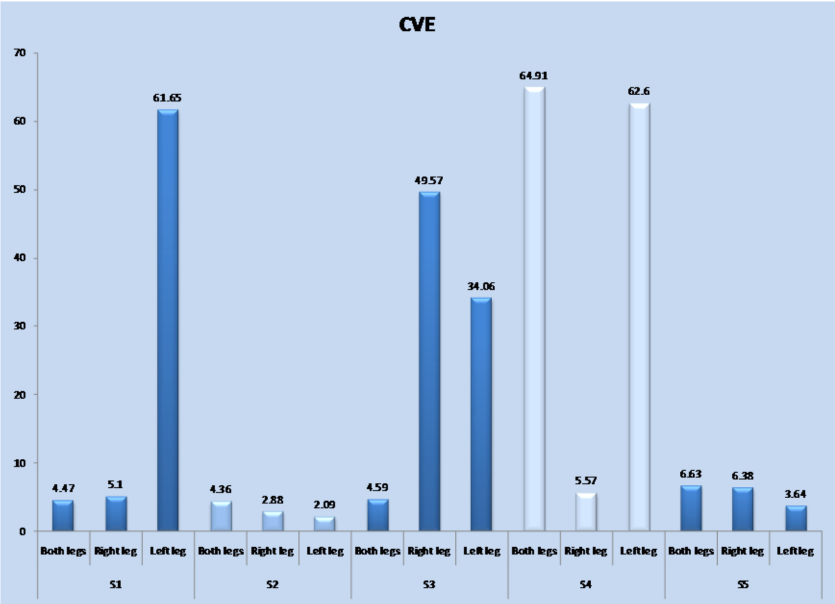
Finally, the fifth athlete has no major differences from the mean of the group, but for the time on air at the jump on the left leg, we can see a greater value than the mean of the group by 14.2%.

The variability coefficients reveal how the athletes' muscles respond to stimuli. Thus, if the ground contact is not achieved at constant intervals in time, it means that the athlete's muscle has different responses to stimuli, and if the intervals of time in air are irregular, it means that the athlete's adaptation to different situation is not so good, and he controls himself less than another person with constant time intervals on air.

The CVE coefficient reveals the automatisms of motions, which is good to be at their highest rate for precise body motion sports and at an optimum rate for contact sports (gymnastics, skating, paddling etc.) and optimum for contact sports (fencing, boxing etc.). A great value for that parameter reveals that the athlete doesn't control the final phases of the motions at high speed.

The CVS coefficient provides information about the capacity of controlling the contact phase with the ground. Thus, we can see (fig. 2.6) that subject 1 has problems controlling his motions on the left leg (CVE=61.65), subject 2 is controlling very well his motions, subject 3 has real problems when he is in the final state of motion on both right and left leg (CVE=49.57, respectively CVE=34.06), while subject 4 has problems when he is in a final state of an action on both legs. We can also see (fig. 2.6) that the first subject has serious problems with controlling the ground contact on the left leg, meaning that he doesn't know his body and doesn't know how to prepare a contact (with an opponent, with a ball or the ground itself).

Some malfunctions might be also ascertained for the subject 4 involved in this study, while its control parameters are greater than the highest accepted value, but he doesn't display major differences from one leg to another, as subject 1 does.



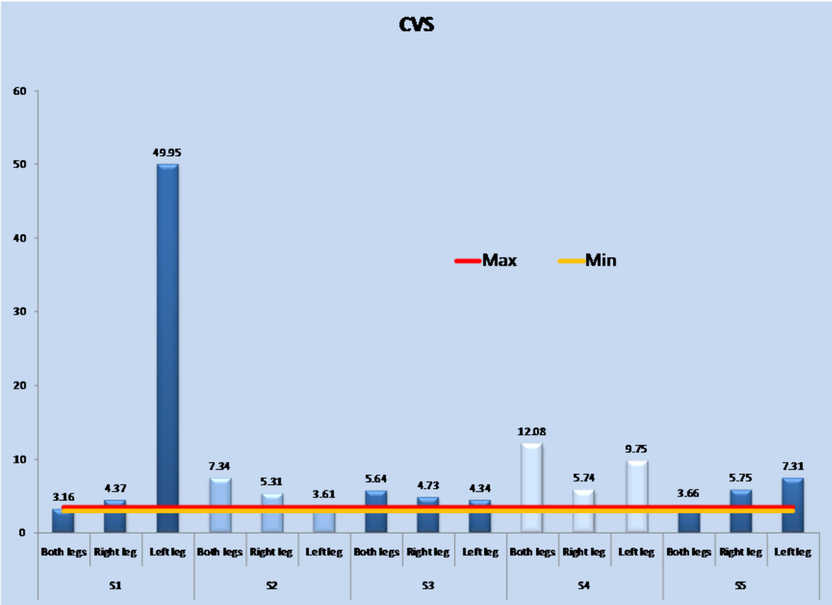


Fig.2. 6 The CVE and CVS control parameters

The energetic parameters reveal that for the first subject (fig. 2.7) the qualities force-velocity are not at their maximum when he jumps on his left leg, while for the jumps on both legs and on the right leg he almost reaches the maximum power possible.

Subjects 2, 3, 4 and 5 seem to have a better development of both qualities, as they are very close to the maximum unit power, in all cases.

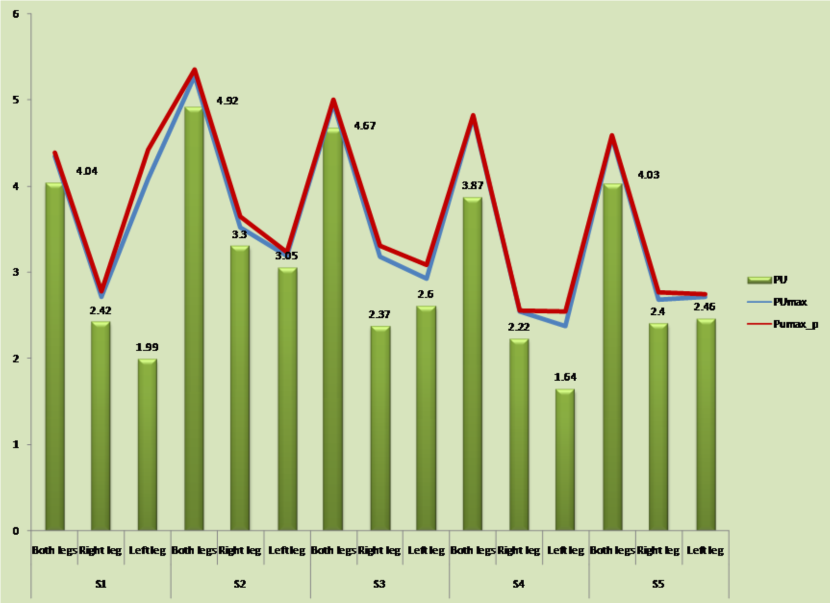


Fig.2.7 Power unit, maximum power and maximum power possible diagrams

For each individual there is a ratio for the qualities force-velocity dependent on the muscular structure which allows a maximum efficiency in effort. The differential power unit between the values computed for both legs, right and left leg reveals the nature of the unbalanced ratio force-velocity, with respect to reference values from literature.

Thus, we can observe (fig.2. 8) that only the subject 5 (-0.83) is close to the optimum ratio force-velocity (=-1), but all the other subjects present unbalanced ratio force-velocity. Subjects 1, 3 and 4 show an unbalanced ratio of force – velocity, which reveals a lack of force in the training process. As for subject 5, we can see that the unbalance (-1.43) reveals an excessive force in training.

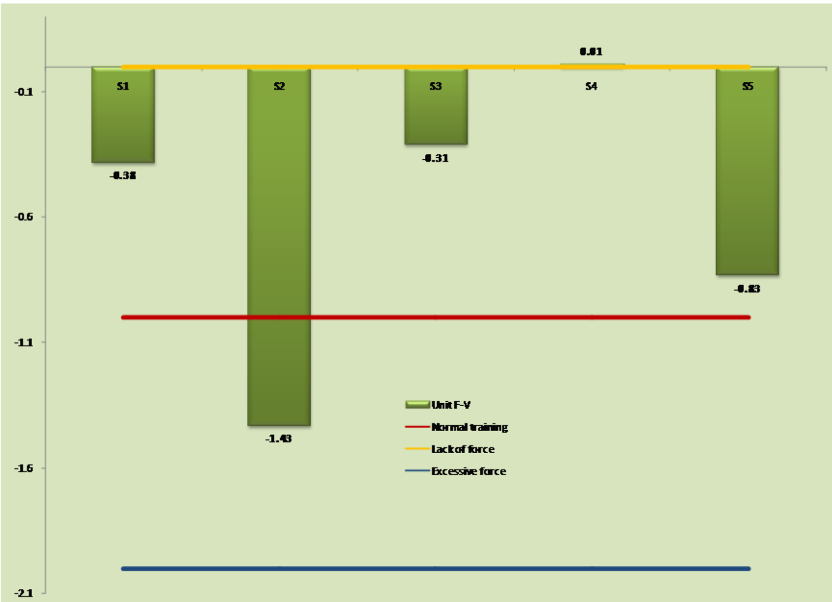


Fig. 2.8 Differential power

As for the skewness we can notice that only for the fifth subject the characteristic force-velocity is symmetrical for the right and for the left leg (fig. 2.9) and we also have good results for athletes 2 and 3.

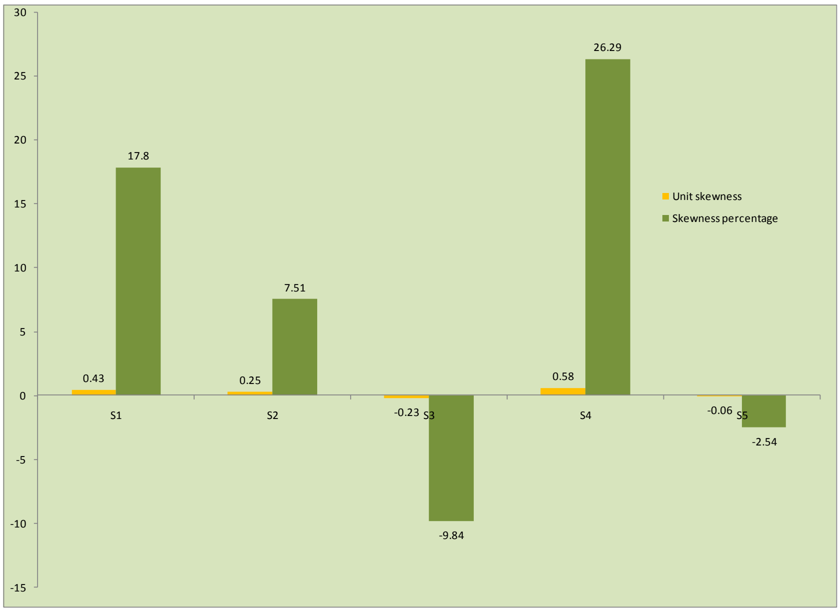


Fig. 2.9 The skewness

Other results have shown the energetic parameters of the football players of the team that has lead the national championship, together with the data analysis (Mereuta, Mereuta, 2012). The MGM test is used as a method to assess the training of elite football players. For the experimental phase a group of 25 football players from the former leader of the Romanian Championship volunteered to participate in the study. All procedures had the prior approval of University's Ethics Committee. After the general purpose of the investigation was explained, sport managers, trainers and all participants gave their consent to conduct the study. For each of the participants, the test provides the ground contact time and the flying time when they performed vertical jumps on both legs, on right and on left leg.

Participant 1 develops an average unit power which is 91.7% from the maximum possible power on vertical jumping on both legs, 90.5% on the right leg and 87.5% on the left leg. The maximum developed power is 99.6% from the maximum possible power on vertical jumping on both legs, 96.1% on the right leg and 96.5% on the left leg. The ratio force – velocity (-1.93) reveals an unbalanced training, with excessive force and lack of velocity (37.8%). As for the energetic asymmetry, that participant has almost the same qualities for the right and left leg (0.94%). The second energetic parameter, that characterizes the force during the effort, reveals the fact that this football player develops 86%-89% of the force during vertical jumping. The third energetic parameter reveals the speed during the effort which is very small for all vertical jumps (fig.2.10).

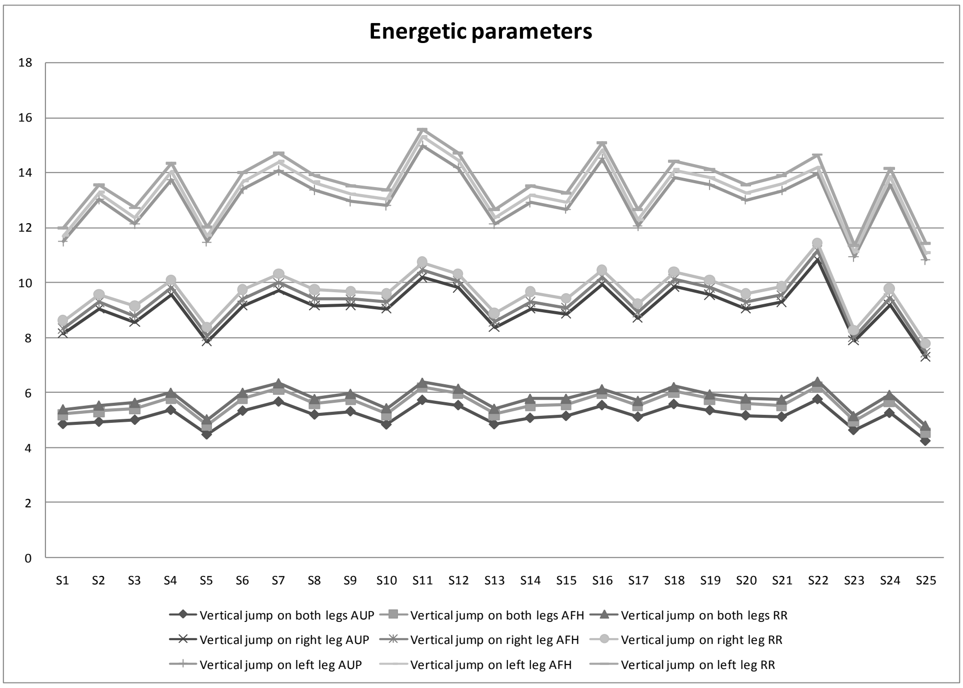


Fig.2.10 Energetic parameters of participants

The same analysis can be performed for all participants at the test, revealing their individual characteristics.

Comparing their results with the average of the team we can see that for the average unit power (fig.2.11) computed on the vertical jump on both legs, 52% of participants develop unit power greater than the mean (5.157). The biggest value of power unit (5.75 – participant 22) is 11.49% greater than the team's average, while the smaller value of power unit (4.24 – participant 25) is 17.78% lower than the team's average.

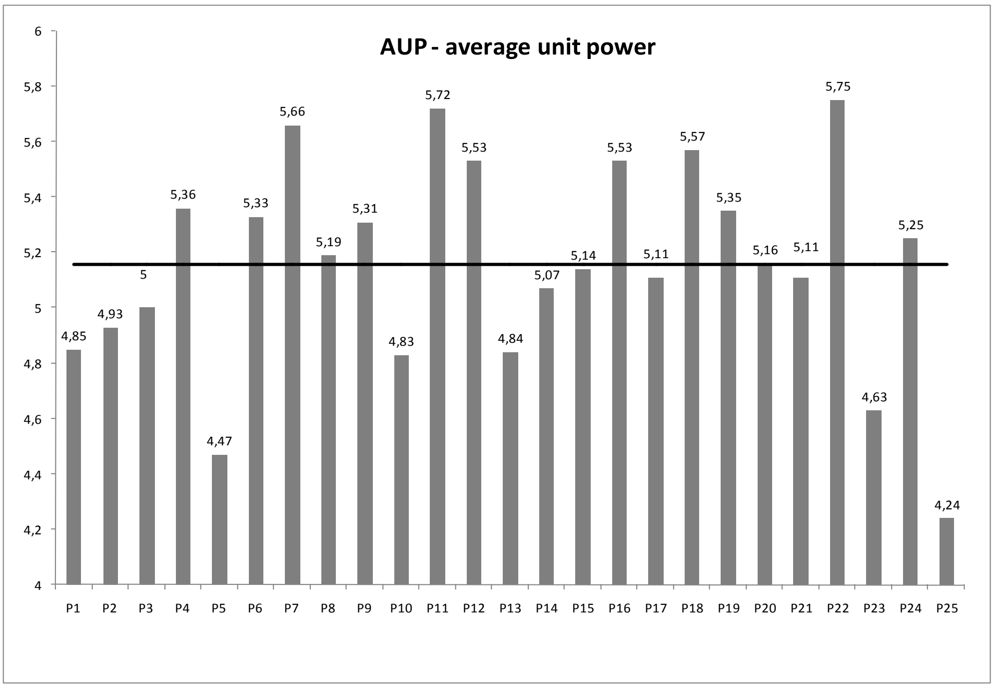


Fig.2.11 Average unit power

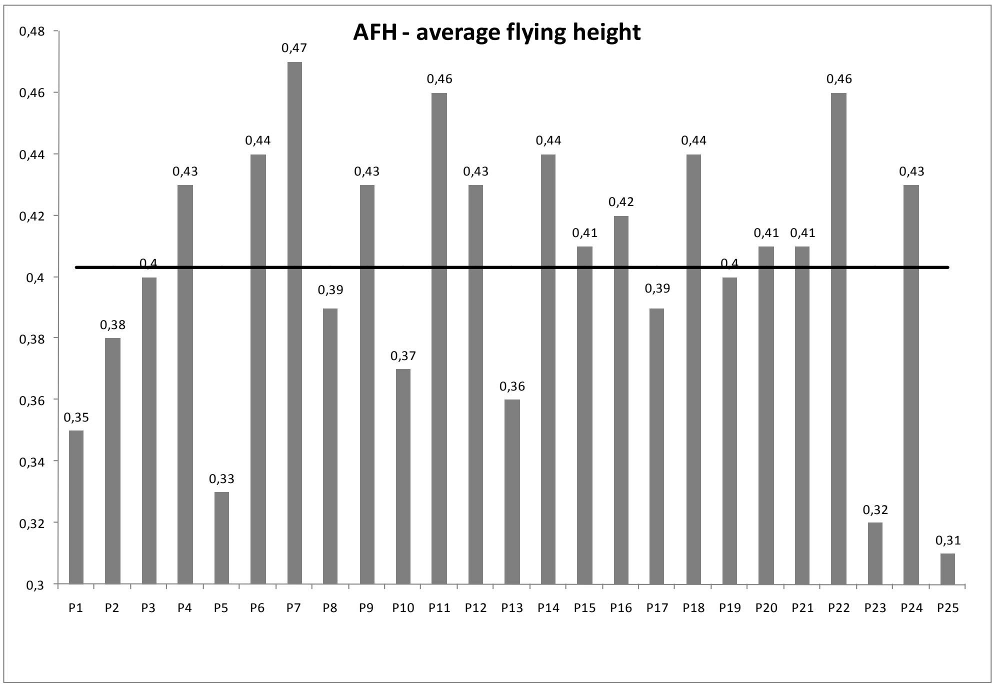


Fig.2.12 Average flying height

For the average flying height (fig.2.12) computed on the vertical jump on both legs, 56% of participants develop values of the energetic parameter greater than the mean (0.403). The biggest value of the parameter (0.47 – participant 7) is 16.56% greater than the team's average, while the smaller value (0.31 – participant 25) is 23.11% lower than the team's average.

The repetition rate (fig.2.13) computed on the vertical jump on both legs, reveals the fact that 52% of participants develop values of the energetic parameter greater than the mean (0.203). The biggest value of the parameter (0.26 – participant 14) is 27.7% greater than the team's average, while the smaller value (0.17 – participant 16) is 16.5% lower than the team's average.

For this energetic parameter, the interpretation of the results reveal the fact that participant 16 (which value of RR is the smallest) has the best performance in velocity effort from the whole team, even though the value ranks him in the group of athletes with normal speed. Seven participants meet the same condition for normal speed effort and shall be considered the best trained football players in speed effort of the team.

A well oriented trainer must prepare individual programs for each football player in order to correct the lack of force, velocity and the force-velocity ratio. It is also important to measure again the energetic parameters after the training stage, in order to reveal that the training program was efficient, accordingly to the required demands.

The complementary parameters achieved while performing a MGM experimental test are also used to assess the physical training of football players. A comparison between the complementary parameters of some football players and the values of the entire group is made (fig.2.14). A regression analysis will reveal if some anthropometric parameters are influencing the data collected from the experiment.

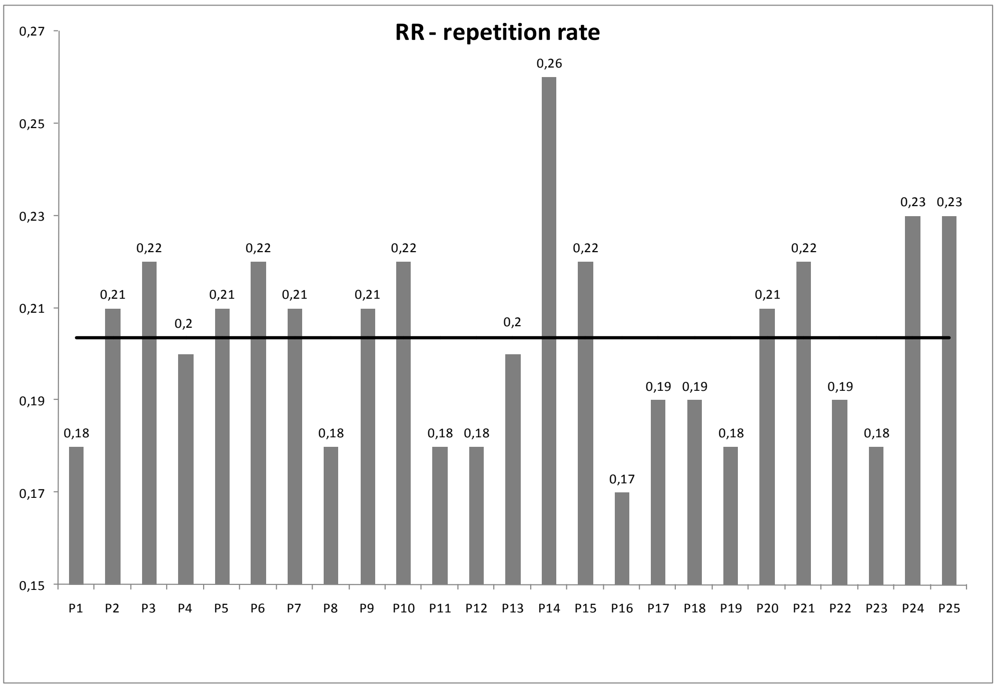


Fig.2.13 Repetition rate

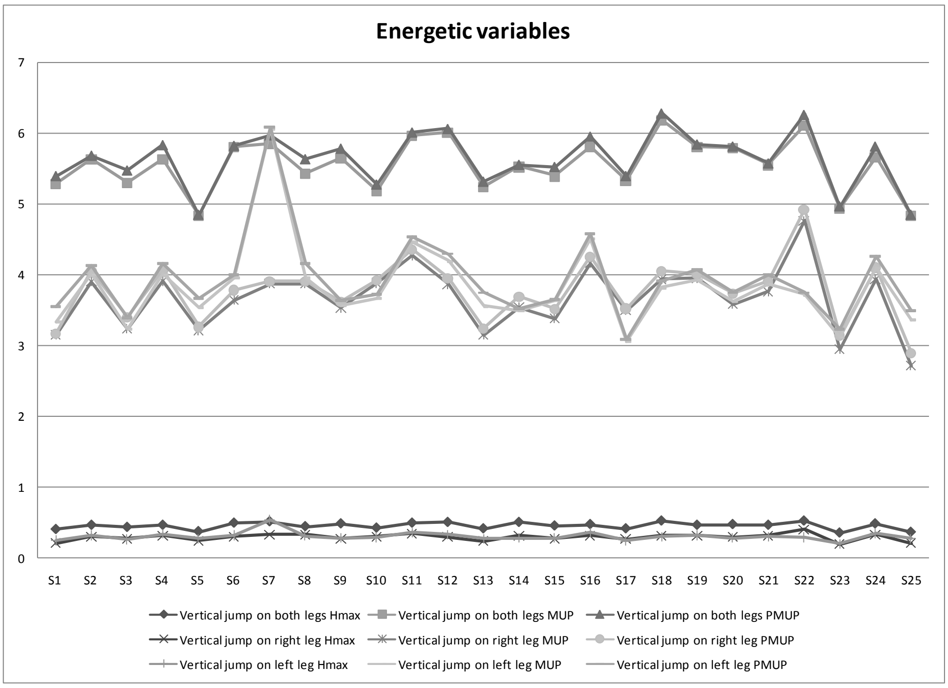


Fig.2.14 Complementary energetic variables

A regression analysis aiming to reveal the influence of two independent parameters (weight and height) prove that only 32.29% of the average vertical height on left leg is influenced by these parameters, while all the other energetic variables have evolutions which are less dependent to the considered independent parameters (fig.2.15). The weight and the height have almost no influence on the repetition rate, which measure the response of the neural processes to stimuli.

As for the other energetic parameters, the fact that the anthropometrical parameters have no influence on their evolution, proves that these parameters are dependent only to the training process and for their improvement, the coach must act accordingly.

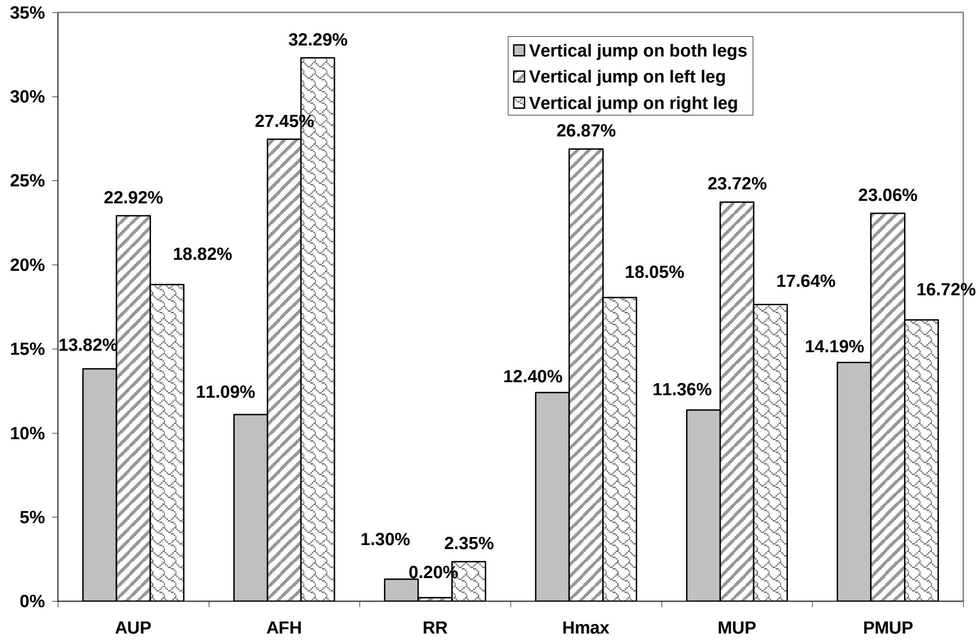


Fig.2.15 Regression analysis

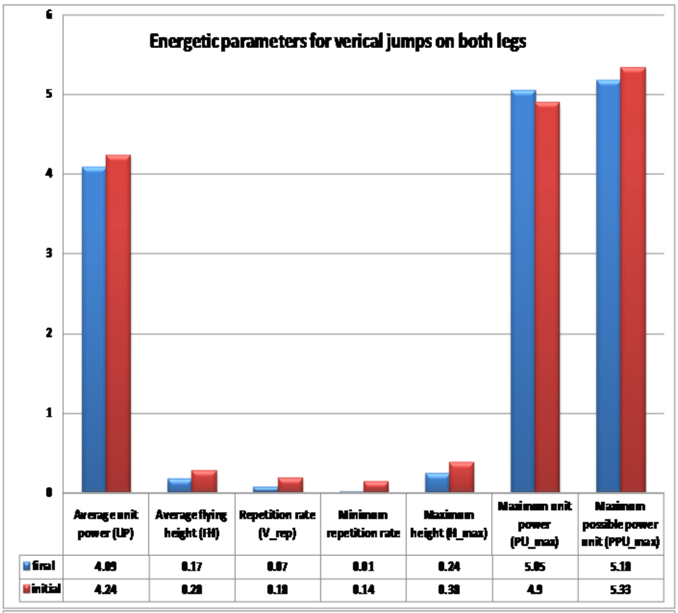
The influence of a tennis player's specific training on the energetic and control parameters can be another application of the MGM test (Mereuta, Mereuta, 2014). It is possible to reveal improvements of some parameters, but also decreases of other parameters. In the experiment took part a junior female tennis player, of 10 years old, with parental agreement on the test. The protocol has been explained to the tennis player and she was tested in two situations. The first test aims to establish the initial state of preparation. Then, she has been subjected to a specific training, and at the end of it was she again tested to assess progress.

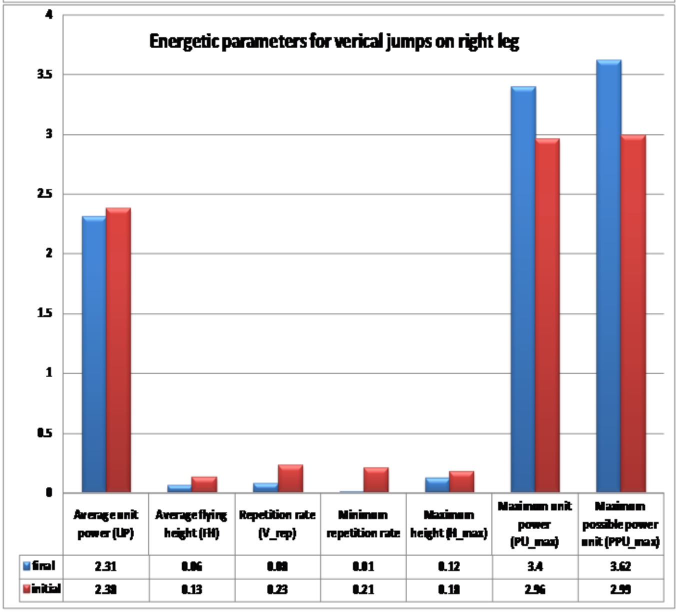
The initial test revealed that there is an imbalance in preparation, with excess of speed and lack of force. The energy asymmetry showed improved quality for the right leg, with percentage differences of 12.98 %. After initial testing, a customized training program has been implemented. We have noticed that the maximum height is degreasing for all vertical jumps, while the maximum unit power is increasing for all jumps (fig.2.16). It is noticeable that the average flying height is 73.68% of the maximum height for the vertical jumping on both legs, 72.22% of the maximum height on right leg and 76.19% of the maximum height on left leg, at the final test.

The maximum possible unit power is increasing for vertical jumps on each leg separately, but decreasing for vertical jumping on both legs.

The repetition rate provides information on the effort highlighting how quickly the excitation and inhibition processes of nerve cells are succeeding, on the one hand, and the processes of contraction and relaxation of muscles, on the other hand. The average value of the parameter values reveals poor velocity abilities, for the initial and final test, with a small improvement at the final test, after the customized training.

The average unit power and the average flying height are decreasing, but the force velocity ratio (-0,5) reveals a small unbalance in training, with excess velocity and lack of force (of 12.27%), for the final test (fig.2.17).The energetic asymmetry shows better qualities for the right leg (1.27%) on the final test.





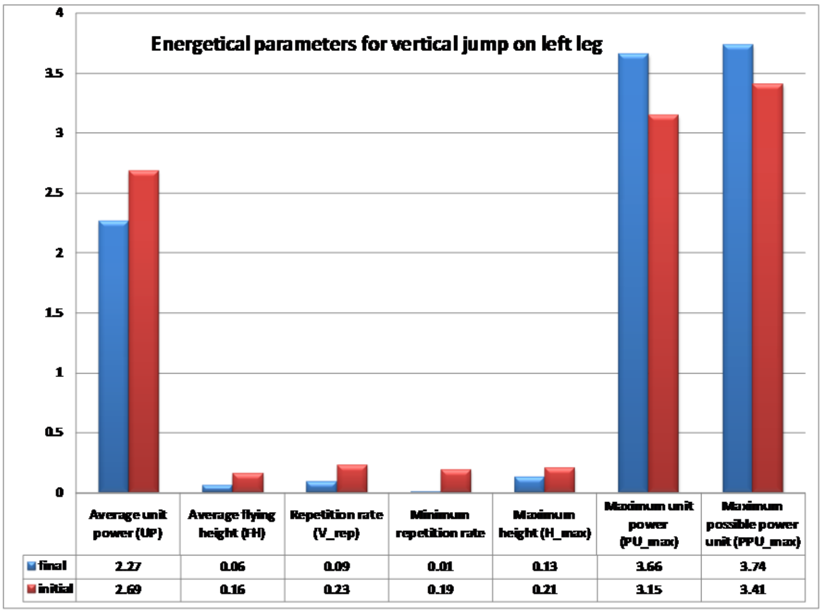


Fig.2.16 Energetic parameters

The energy variation coefficient is increasing for all vertical jumps (fig. 2.17). The structural variation coefficient (CVS) refers to the ability to control the ground contact preparation, the contact with the opponent, with the ball, and the preparation and catching the launched objects. High values of the parameter, over optimum from literature (3-3.5) for all jumping, reveal a lack of control of the female tennis player during ground contact, which can be extended to other types of contacts: with tennis ball, with opponent. The athlete does not anticipate the contact phases she does not catch well, is rigid, and drops objects. A better behavior is registered for the left leg (fig.2.17). The power asymmetries are shown in fig.2.18.

The MGM test revealed that the training process must be customized in order to improve some motrical abilities of an athlete. Even if not all parameters have been improved for the female tennis player, further training programs might do for other parameters.

For the young female tennis player we did get better results, but important is the fact that she has improved her relative parameters, with respect to maximum values, for the final test.

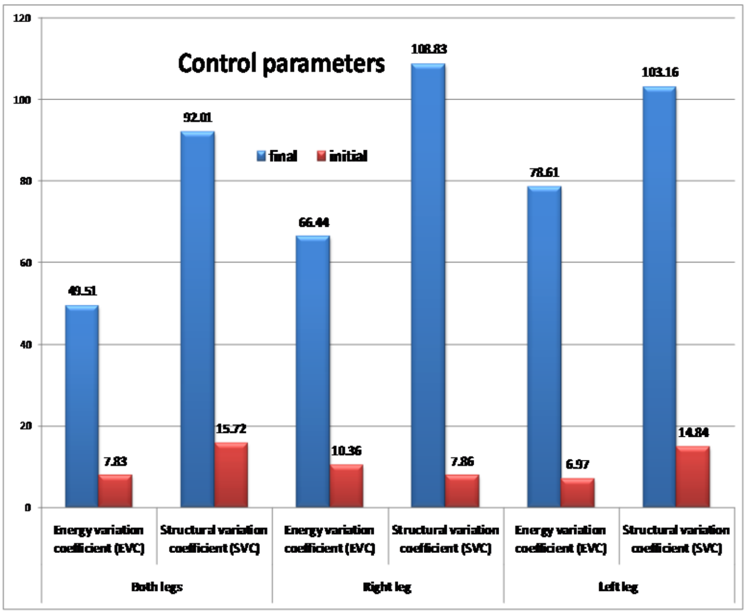


Fig. 2.17 Control parameters

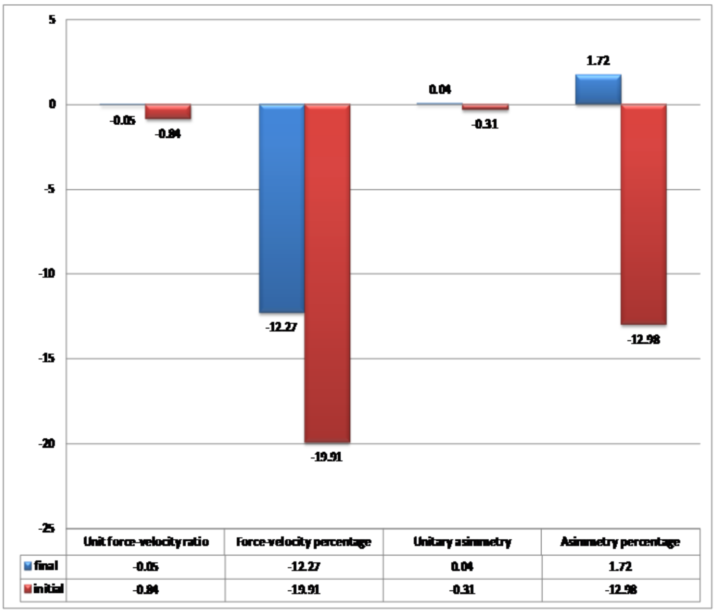


Fig. 2.18 Power asymmetries

Another study has revealed the influence of plantar surface on energetic and control parameters (Mereuta, Mereuta, 2013). The plantar surface considered as variable has proved to be insignificant to energetic and control parameters, but considering other variables related to plantar surface, like conventional pressure and conventional density, we were able to reveal a significant influence using the regression analysis.

The plantar surface (PS) is calculated using the formula established by Thomas G McPoil [7]:

$$PS = -45.18 + (13.72 \times B) + (15.21 \times C) + (-164.14 \times AHR) \quad (2.8)$$

where B is the mid-foot width, C is the heel width and AHR the arch height ratio.

In order to determine the influence of anthropometric parameters on the energetic and control parameters, we have performed regression analysis for each parameters determined using MGM test. We have established the influence of a conventional pressure and density, determined using the weight, the plantar surface and height. The results are shown in Table 2.2 and 2.3.

Table 2.2. Regression analysis for energetic parameters - R-Square values.

Energetic parameter	Height [cm]	Weight [kg]	Plantar Surface [cm^2]	Conventional pressure [kg/cm^2]	Conventional density [kg/cm^3]
Average unit power	5.9%	5.79%	6.17%	52.86%	**47.80%**
Average flight height	1.16%	47.15%	1.33%	47.35%	**46.31%**
Repetition rate	36.8%	7.12%	34.33%	1.22%	**0%**

Table 2.3. Regression analysis for control parameters - R-Square values.

Control parameter	Plantar Surface [cm^2]	Conventional pressure [kg/cm^2]	Conventional density [kg/cm^3]
Energetic variability coefficient	2.91%	12.52%	**11.85%**
Structural variability coefficient	4.94%	0.2%	**0.15%**

The regression analysis has revealed that 52.86% of average unit power variation is determined by the conventional pressure, while the influence of conventional density is 47.80%. The anthropometric parameters (height, weight and plantar surface) have a small influence on that energetic parameter which is not significant.

The average flight height is significantly influenced by weight (47.15%), by conventional pressure (47.35%) and by conventional density (46.31%). The participants' height is the most significant influence factor for the repetition rate (36.8%), while the conventional pressure has influence on that energetic parameter.

As for the control parameters, we can conclude that the anthropometric parameters have no significant influence, meaning that the muscle response to stimuli is not depending on the anthropometric parameters.

The average power can be calculated using different formulas experimentally determined, using either the mass and the vertical jump height, or the flight periods of time and the periods on the ground (Mereuta, Talaghir, 2011). Different formulas were used as follows:

- Lewis's formula uses the mass and the jump height as input data;

- Harman's formula provides the average power and the peak power, using regression method;
- Johnson's and Bahamonde formula uses the mass, the jump height and the athlete's height as input data;
- Sayers's formula provides the average power using the same input data as Lewis, but with different coefficients;
- Georgescu's formula is based on Bosco's theory and it uses the flying times and ground times as input data.

The average power is calculated using Lewis's, Harman's, Johnson's & Bahamonde, Sayers's, Bosco's and Georgescu's formulas (Johnson,1996, Harman,1991, Sayers,1999, Bosco,1983). Then, a comparative analysis is performed.

The results are shown in table 2.4

Table 2.4 –Experimental results

	S1	S2	S3	S4	S5
Height [cm]	167	158	183	173	174
Mass [kg]	64	53	74	67	78
Jump distance [m]	0.32	0.4	0.39	0.34	0.35
P[Lewis]	801.4	742	1022.9	864.7	1021.4
P[Harman]	751.96	667.2	1129.17	863.02	1137.05
P[Johnson, Bahamonde]	1119.8	1261.7	1484.6	1204.7	1591.4
P[Sayer]	863.624	370.18	1320.87	1000.73	1499.64

The values for Bosco's test are shown in table 2.5 and the the magnitude of the average mechanical power using MGM test is shown in fig. 2.19.

Table 2.5 Values of Bosco's test

	S1	S2	S3	S4	S5
Total time	7.739	7.867	8.237	6.074	7.8
Time on air	5.341	5.944	5.926	3.949	5.351
Power	41.478	58.515	50.827	27.155	41.014

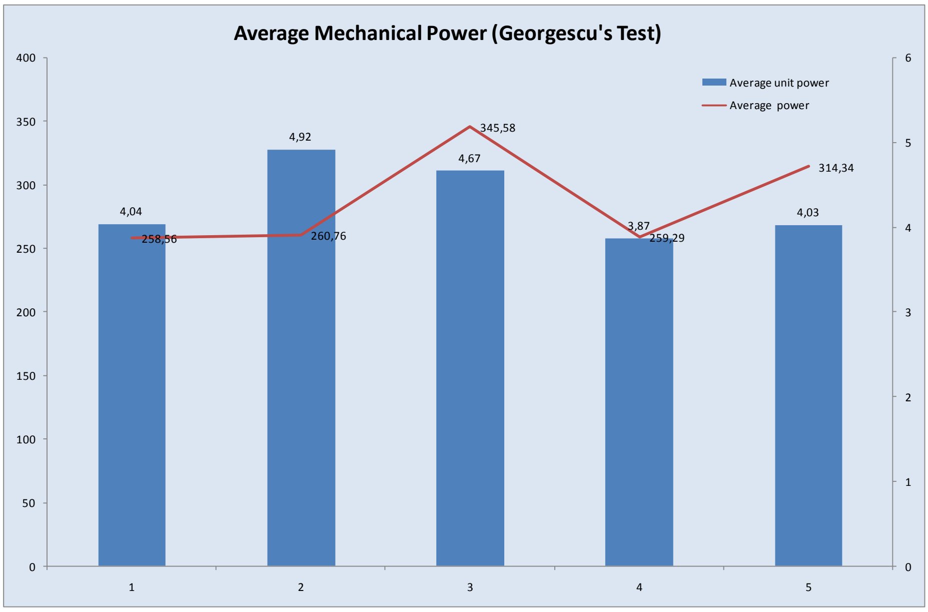


Fig.2.19 The average mechanical power by MGM

We conclude that the Harman's test can be considered as the most accurate test for average mechanical power, as its procentual deviation from the average power is smaller than the other tests (fig.2.20).

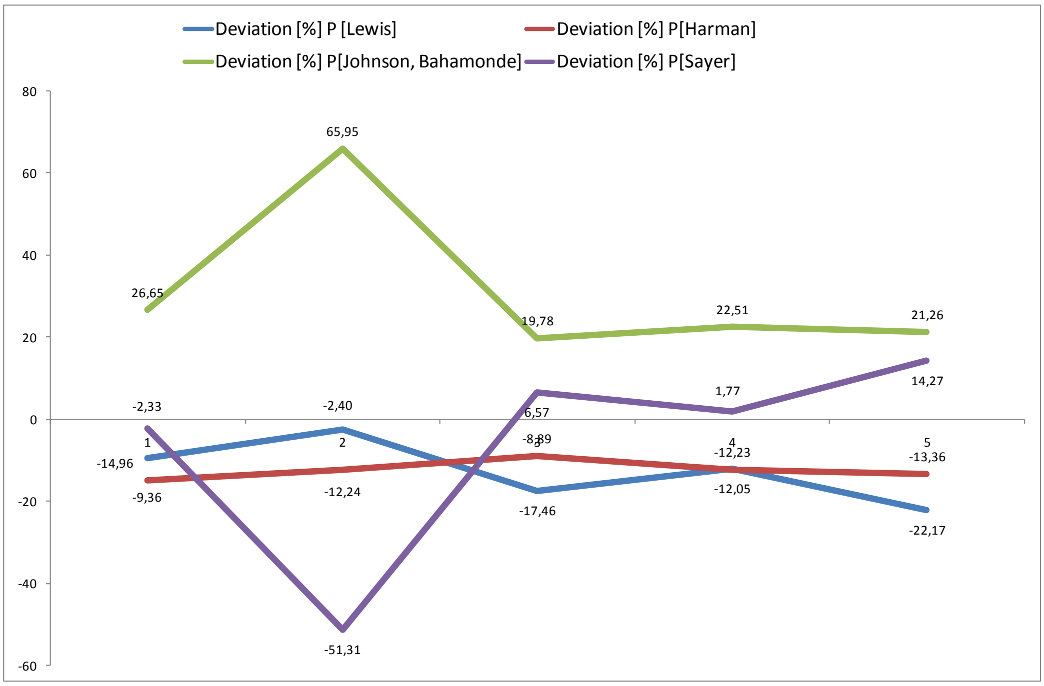


Fig.2.20 Deviation of average mechanical power determined with different test from the average

There are important differences between one test and another, regarding the magnitude of the average mechanical power, although they are using the same input data. Thus, the comparison shows that for subject 4 the difference between the average power calculated with Lewis's formula and the average power calculated with Farman's formula is the smallest (-0.2%), while for subject 2 we get the maximum difference between the average power calculated with Lewis's formula and the average power calculated with Johnson's & Bahamonde formula (70.04%).

Such large differences prove that none of the fourth test is relevant to the estimation of average power. As for the last two tests (based on the multiple vertical jumping) we can reveal that there are also significant differences due to the fact that Miron Georgescu's test provides the average unit power (fig.2.21).

Another study involved in this research area aims at determining the influence of somatic parameters on the energetic and control parameters determined during the MGM test (Mereuta, Talaghir, 2011). The method used to estimate that influence is regression that takes into account two independent parameters of influence (the height and the weight). Considered together, both somatic parameters have a certain influence on the energetic parameters, while individually, their influence is not significant.

The regression method is a method of research of the link between variables using a regression function. Regression function expresses the quantitative change of the characteristic output (y) as a result of the influence of factorial parameters (x), the other factors being considered non-essential. For the multiple linear regression, the regression equation is therefore of the form:

$$Y = f(X_i) = \alpha_0 \cdot X_0 + \alpha_1 \cdot X_1 + \alpha_2 \cdot X_2 + \alpha_3 \cdot X_3 + \cdots + \alpha_{p-1} \cdot X_{p-1} + \varepsilon \quad (9)$$

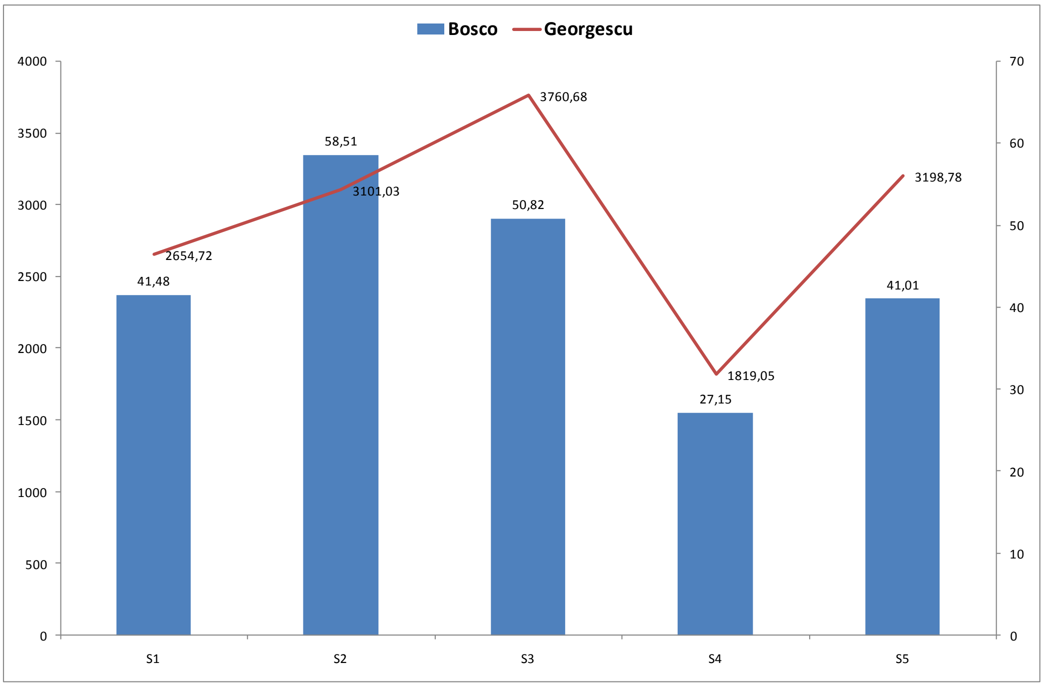


Fig. 2.21 Differences between Bosco and Georgescu test

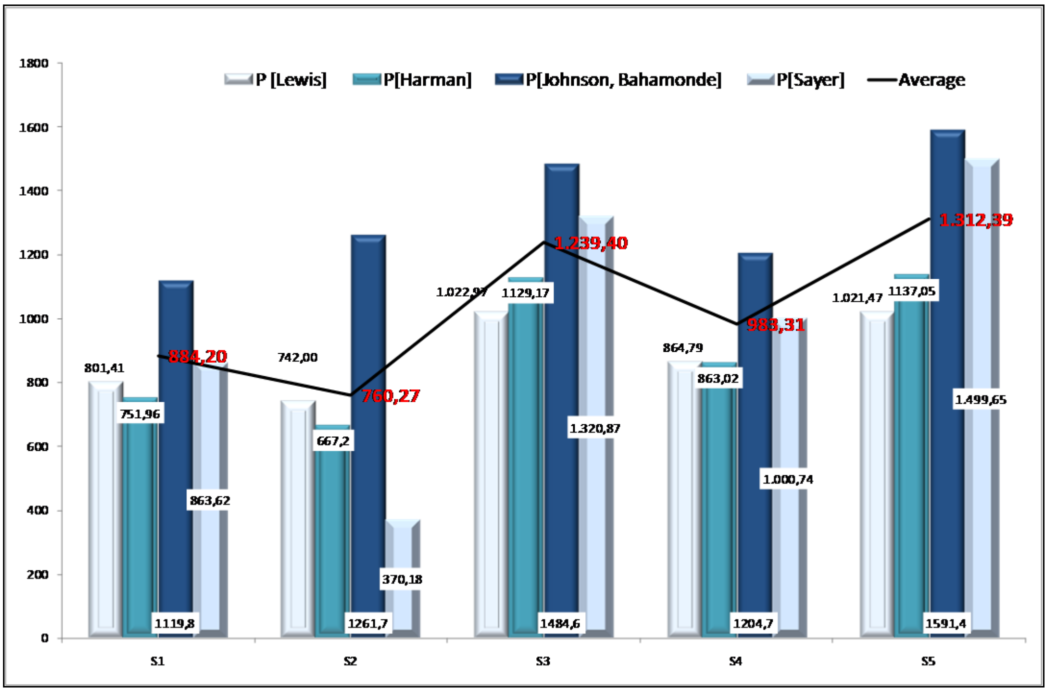


Fig.2. 22 Comparative diagrams of average mechanical power

Once calculated the estimated regression coefficients, several statistical tests should be performed. They must be capable of providing information about the statistical significance and on the ability to provide forecasts. The most important statistical calculations and tests are:

- Calculation of standard deviation;
- Calculation of the ratio between dispersions F;
- Calculation of the determination coefficient R2;
- T test.

The regression statistics for the energetic parameters for vertical jump on both legs are shown in table 2.6. They reveal the fact that the influence of both somatic parameters on the energetic parameters is 11.85% for AUP, 10.5% for AFH and only 0.7% for RR.

Table 2.6 Regression statistics

Regression Statistics			
	AUP	AFH	RR
Multiple R	0.3442	0.3240	0.0855
R Square	0.1185	0.1050	0.0073
Adjusted R Square	0.0009	-0.0144	-0.1250
Standard Error	0.6513	0.0657	0.0308
Observations	18	18	18

The intercepts and the regression coefficients allow expressing the estimated regression function for each energetic parameter.

$$AUP_{both\ legs} = 3.5274 + 0.018 \cdot Height - 0.0326 \cdot Weight$$

$$AFH_{both\ legs} = -0.0082 + 0.034 \cdot Height - 0.003 \cdot Weight$$

$$RR_{both\ legs} = 0.3093 - 0.0005 \cdot Height + 0.0001 \cdot Weight$$

The regression analysis performed on the energetic parameters revealed that the influence of both somatic parameters is different from one energetic parameter to another. Thus, for the AUP at vertical jump on both legs, the influence is 11.85%, for the AFH energetic parameter, the influence is 10.49%, while for RR energetic parameter is approximately zero.

Regarding the influence of the somatic parameters while performing jumps on left, right and on both legs, we conclude that for the AUP parameter, the biggest influence of the somatic parameters was computed for the vertical jump on left leg (15.15%), for AFH parameter the biggest influence of the somatic parameters was computed for the vertical jump on right leg (21.93%). As for the RR parameter, the biggest influence was computed for the vertical jump on left leg (16.22%).

The regression statistics for the dependent variable CVE and CVS on both legs are shown in table 2.7.

Table 2.7 Regression statistics for CVE and CVS

Regression Statistics	CVE	CVS
Multiple R	0.5939	0.39251
R Square	0.3527	0.154064
Adjusted R Square	0.2664	0.041272
Standard Error	17.9008	16.50178
Observations	18	18

The proposed models for CVE and CVS control parameters are:

$$CVE_{both\ legs} = -378.7594 + 1.9542 \cdot Height + 0.5802 \cdot Weight$$

$$CVS_{both\ legs} = -123.522 + 0.5197 \cdot Height + 0.6506 \cdot Weight$$

The analysis provided by the regression method on the influence of the somatic parameters upon the control parameters, reveals the fact that, considered together, the two somatic parameters (height and weight) have a certain influence on the control parameters (CVE and CVS), respectively 32.57% on CVE and only 15.4% on CVS, although, considered individually, their influence is not significant.

The analysis was performed on the control parameters computed from the MGM test, for the vertical jumps on both legs. Further analysis will reveal if there is any influence on the control parameters computed while the athletes perform vertical jumps on left and right leg.

The MGM test was also used to determine the influence of spatial perception on the control and energetic parameters measured in three cases: while the participant visualizes his performance, blindfolded and while he performs standard test for energetic and control parameters (Mereuta, Ganea, 2014). The experimental system used to analyze the influence of spatial perception is based on the Kinect depth sensor and tailor made software which allows the initialization and the computation of kinematic parameters.

Sports intelligence is an important factor in success or failure in sport (Niculescu, 2000). Considered to be a particular form of general intelligence, but different in substance, this concept occurs and grows in relation to the sport activity proving the adjustment to the requirements of training, contributing to the changes occurring during different training stages (Tudos, Mitrache, 2006).

Sports intelligence can be defined as the availability and assimilation harmony of sports requirements, together with personal adaptation to them. It is well known that motor intelligence completes psycho-motricity scheme, along with other components: coordinative abilities, ideo-motricity, body scheme, speed movements and praxis. This psycho-motor component received over time many definitions as psycho-motor intelligence, special aptitude, cognitive organization, adaptability etc.

According to Gagea (1999), motric intelligence is expressed through some specific features as: motor memory, creativity, motor skills, and spatial - temporal sense.

The authors (Colibaba, Bota, 1998) argue that motric intelligence is a very important factor in athletes' training program. It appears as an adjustments of already automated movements (Ichim, Ion-Ene, 2001), to constantly changing playing conditions, new movements and new technical execution styles etc.

The energetic parameters and the control parameters are provided by the MGM test for three conditions to which the athletes were subjected (table 2.8).

Table 2.8. Experimental results

	ENERGETIC PARAMETERS			
	Parameter	**Blind folded**	**Visualizing the motion**	**According to protocol**
Vertical jumping on both legs	Average unit power	3.69	4.23	4.34
	Average flying height	0.25	0.3	0.32
	Repetition rate	0.23	0.22	0.22
	CONTROL PARAMETERS			
	Parameter	**Blind folded**	**Visualizing the motion**	**According to protocol**
	Energetic variability coefficient	8.09	6.34	7.53

	Structural variability coefficient	18.84	18.22	18.65
Vertical jumping on right leg	**ENERGETIC PARAMETERS**			
	Parameter	**Blind folded**	**Visualizing the motion**	**According to protocol**
	Average unit power	2.1	3.89	2.97
	Average flying height	0.13	0.26	0.2
	Repetition rate	0.28	0.2	0.26
	CONTROL PARAMETERS			
	Parameter	**Blind folded**	**Visualizing the motion**	**According to protocol**
	Energetic variability coefficient	10.16	15.33	14.85
	Structural variability coefficient	11.02	40.59	19.19
Vertical jumping on left leg	**ENERGETIC PARAMETERS**			
	Parameter	**Blind folded**	**Visualizing the motion**	**According to protocol**
	Average unit power	4.75	2.66	2.37
	Average flying height	0.37	0.18	0.16
	Repetition rate	0.28	0.3	0.32
	CONTROL PARAMETERS			
	Parameter	**Blind folded**	**Visualizing the motion**	**According to protocol**
	Energetic variability coefficient	54.54	8.83	7.18
	Structural variability coefficient	10.09	13.35	11.26

In addition, in fig. 2.23 the influence of spatial perception on the energetic parameters for vertical jumping test on both legs is revealed.

Fig. 2.23. Energetic and control parameters for vertical jumping test on both legs

Thus, the average unit power increases (14%) when the athlete performs vertical jumps on both legs and visualizes his performance, comparative to the blindfolded situation. However, the proportion of the maximum power developed on vertical jumping on two legs, it is found that the best values are recorded for the standard test case (84.71%).

As far as that goes, the average flying height it is found to be maximum with respect to maximum height, for the standard test (84.21%), but when the athlete visualizes his performance, the parameter is 20% greater than for the blindfolded case.

The repetition rate for all the cases proves that the athlete has poor velocity.

Regarding the control parameters, it is revealed that the best value for energetic variability coefficient is provided by the test conducted with visualization of motion (6.24) proving that in this case the athlete has a better control on its own energetic resources. As for the structural variability coefficient it also registers the best values (18.22) in this test case.

In fig. 2.24 the influence of spatial perception on the energetic parameters for vertical jumping test on right leg is revealed. The same analysis on energetic and control parameters can be performed.

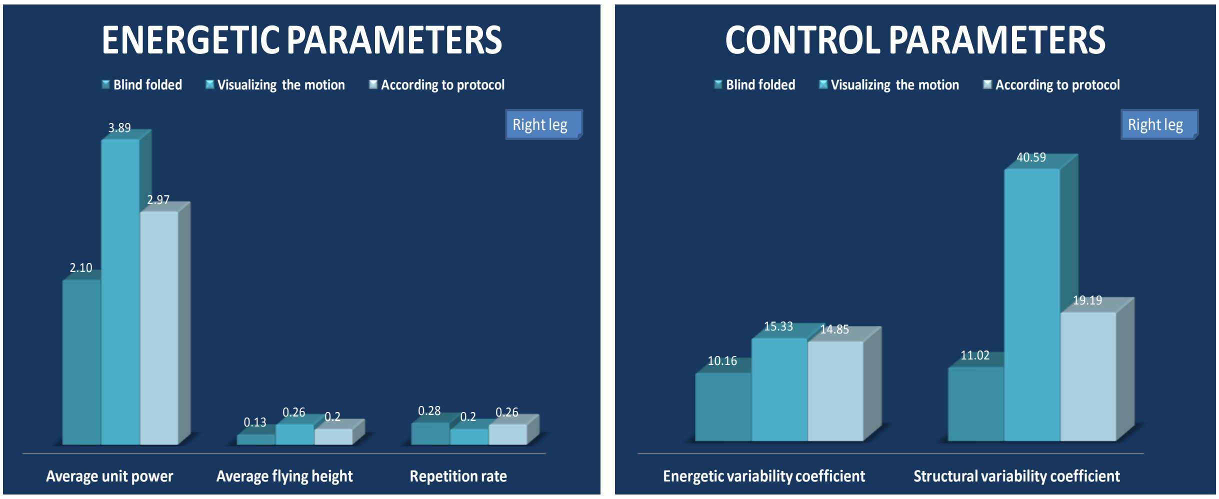


Fig. 2.24. Energetic and control parameters for vertical jumping test on right leg

In fig. 2.25 the influence of spatial perception on the energetic parameters for vertical jumping test on left leg is revealed. Fig. 2.26 shows that the force velocity ratio is better when the athlete visualizing its performance, compared to the blindfolded case. As for unitary asymmetry it is proved that better results are obtained also in this testing case (fig. 2.27).

This experiment proves that there is an important influence of the spatial perception on the energetic and control parameters. Thus, it is proved that for all the participants in the test the energetic parameters are influenced by the spatial perception, proving that the athletes are aware of their performance and try to emphasize their best motric qualities, like velocity and force (Badiu, Ion-Ene, Robu, et. al. 2001).

The test was irrelevant to left foot jumps, maybe because that all tested athletes are right-handed. Better results were observed while performing vertical jumps on right leg.

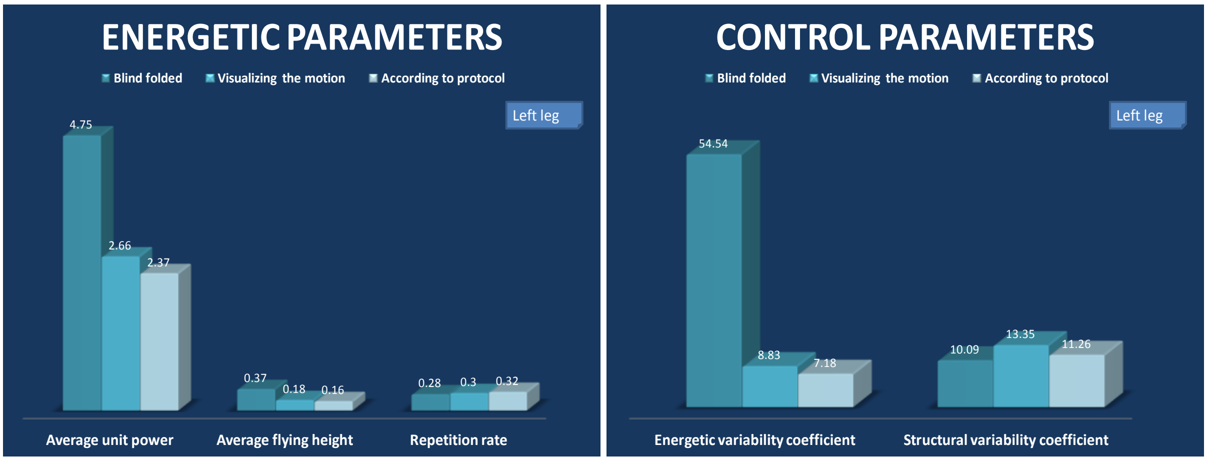


Fig. 2.25. Energetic and control parameters for vertical jumping test on left leg

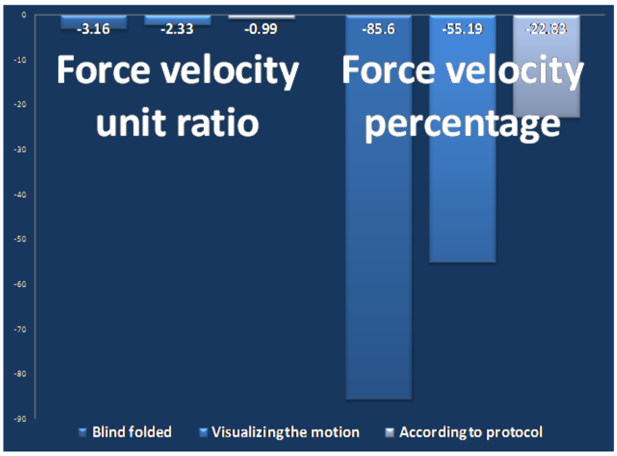


Fig. 2.26. Force velocity ratio

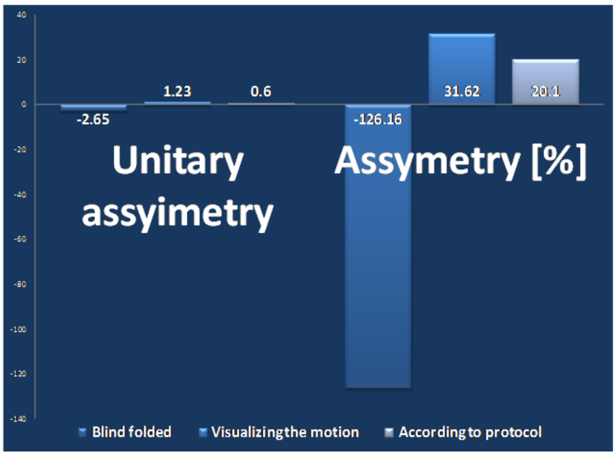


Fig. 2.27. Unitary asymmetry

A study on the influence of body mass index (BMI) and ponderal index (PI) on the energetic and control parameters was also an analysis theme (Mereuta, Talaghir et al., 2011). A group of 12 girls, studying physical education and sports was tested, aiming to reveal if these two parameters have any effect on their physical preparation.

The body mass index and the ponderal index are used to estimate the distribution of mass along the body. While the body mass index (BMI) named also Quetelet index offers a heuristic estimation of the percentage of body fat.

It can be calculated using equation (10):

$$BMI = \frac{mass[kg]}{height^2[m^2]} \qquad (2.10)$$

The statistics reveal that for Romania, the body mass index for adults is between 18.5 and 24.99 kg/m^2.

The ponderal index is more suitable for estimating the body fat percentage providing a more accurate comparison between subjects of different weights and statures.

The ponderal index can be calculated using equation (2.11):

$$PI = 1000 \cdot \frac{\sqrt[3]{mass[kg]}}{height[cm]} \qquad (2.11)$$

The normal results for this index are between 20 and 25.

Analyzing the data we can observe that for the energetic parameters shown in figure 2.28, 50% participants develop an average unit power parameter and a repetition rate over the mean of the group, while 41.67% participants develop the energetic parameter average flying height over the mean of the group.

For the control parameters shown in figure 2.29, we have concluded that only 25% participants develop a CVS control parameter over the mean of the group, while 58.33% participants develop the control parameter CVE over the mean of the group.

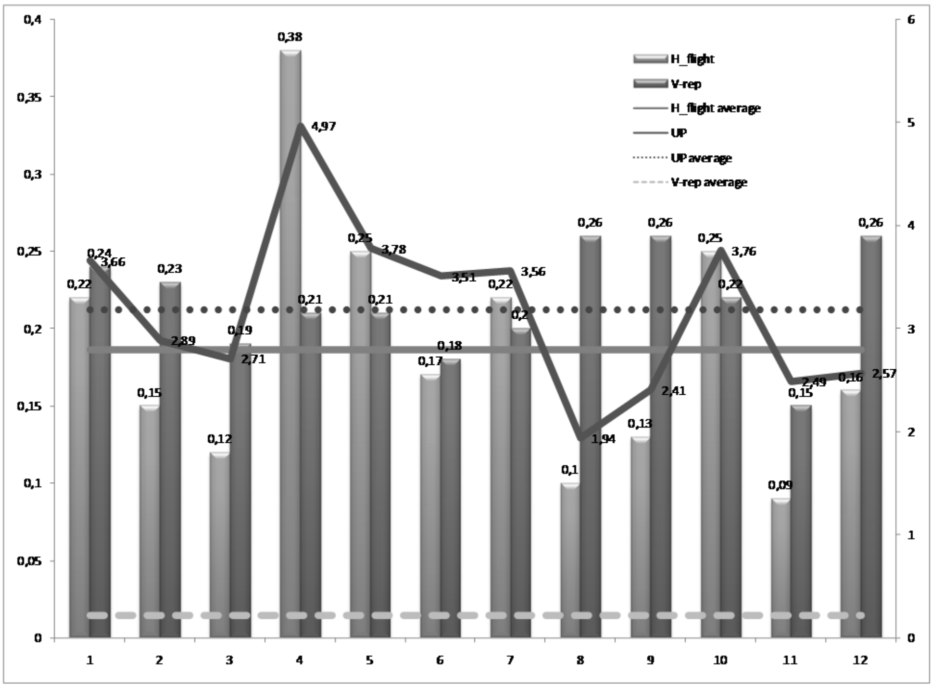


Fig.2.28 The energetic parameters

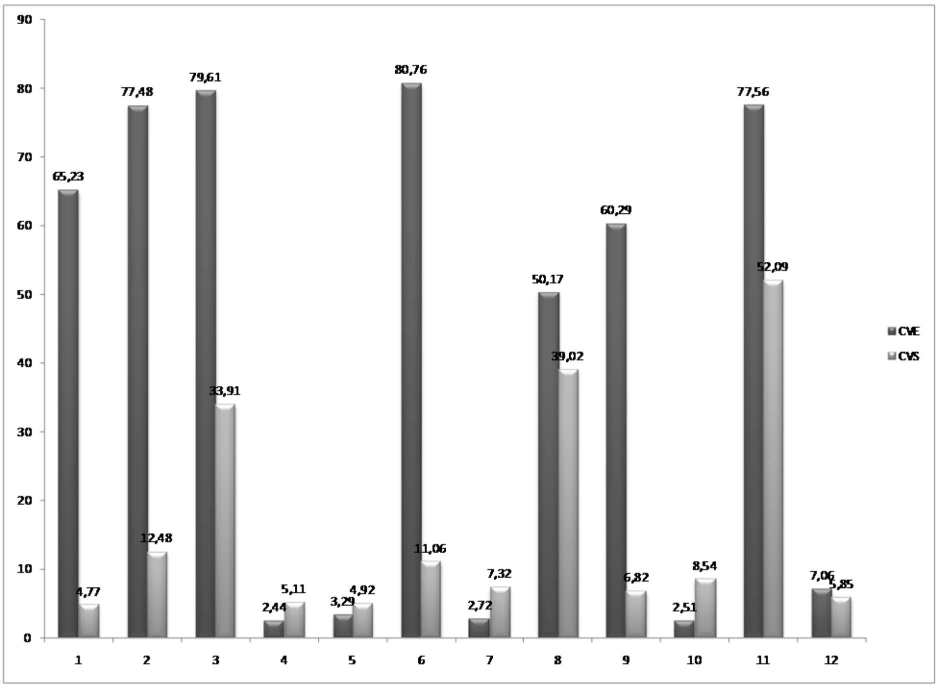


Fig.2. 29 The control parameters

As we can see in figure 2.30, only two participants are below the minimum value of BMI, while the rest of them can be considered as having normal distribution of body fat. In fig. 2.31 the variation of ponderal index is shown. All participants are within the normal range of the ponderal index.

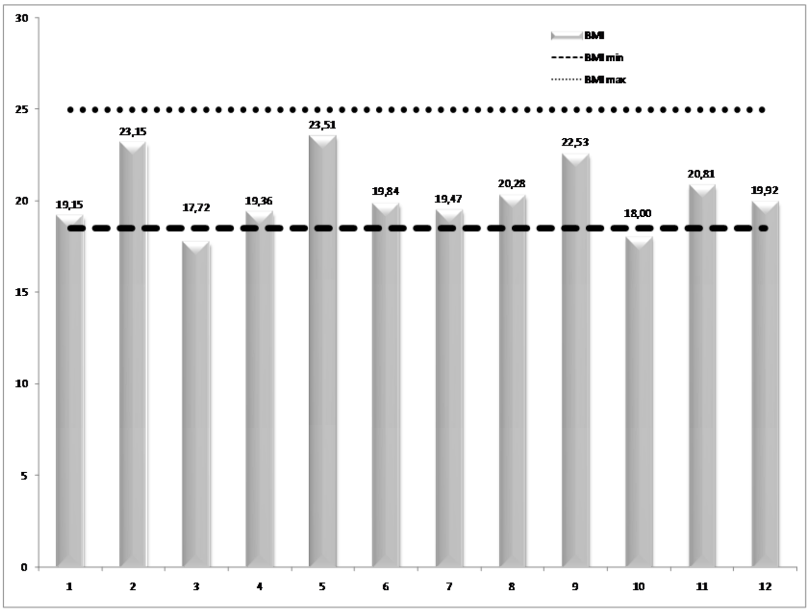


Fig.2. 30 Body Mass Index

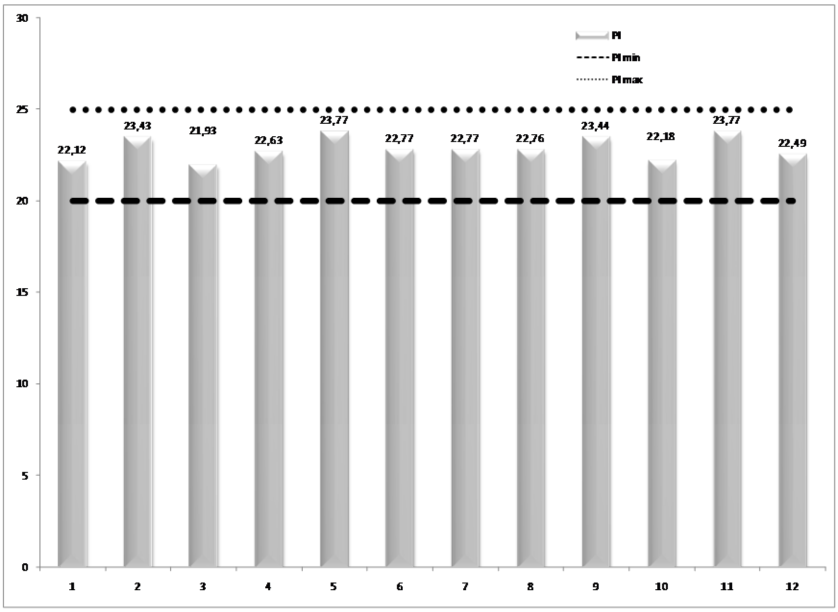


Fig. 2.31 Ponderal Index

The regression analysis revealed that there is no influence of the considered indices on the variation of the energetic and control parameters (fig. 2.32, fig. 2.33). The significance F provided by that analysis must be compared with the critical value. If the significance F is greater than the critical F, we must reject the null coefficient hypothesis. For all our participants in the experiment, the regression analysis proved that the different values of the control and energetic parameters are not influenced by the fat body distribution, concluding that only the level of physical preparation affects the magnitude of the considered parameters.

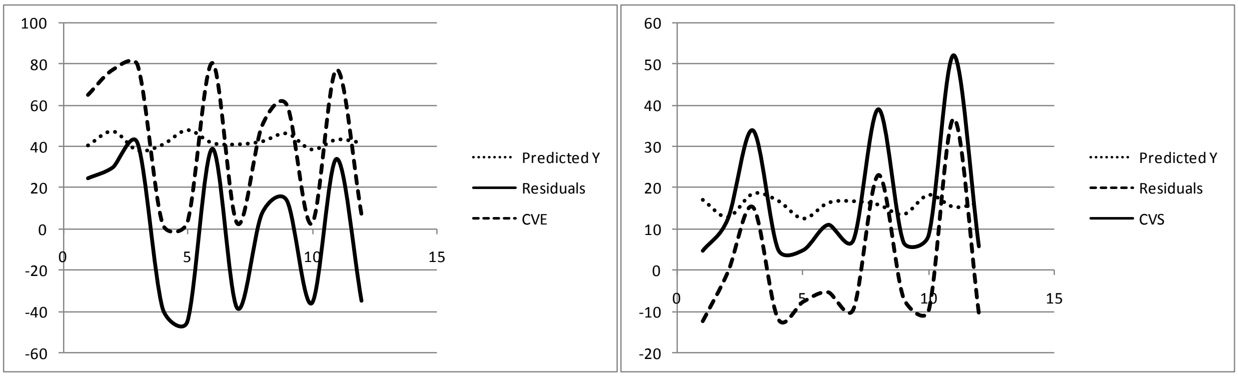


Fig. 2.32 The linear models of the control parameters and the residuals for BMI

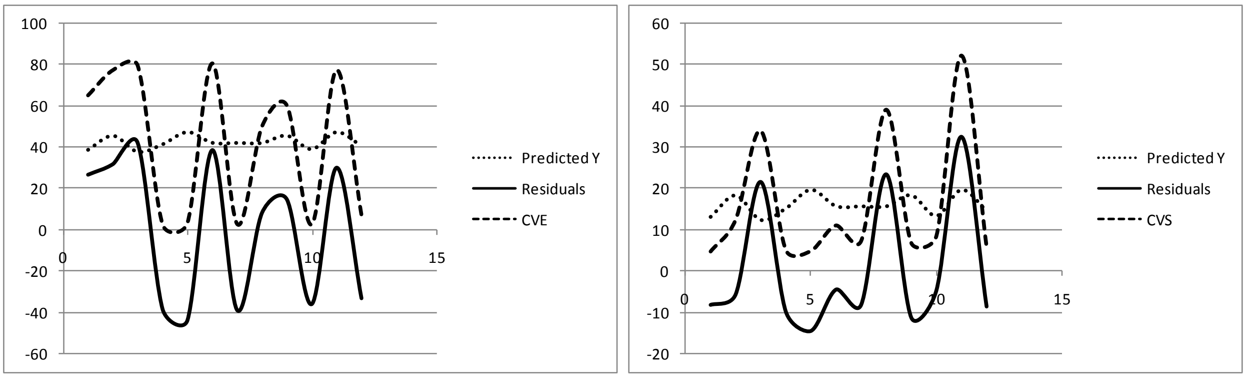


Fig. 2.33 The linear models of the control parameters and the residuals for PI

Thereby, the influence of body mass index is placed in the range 0,8% - 4%, while the influence of ponderal index is placed in the range of 0,9% - 3,75% (table 2.9).

Table 2.9 – The range influence of BMI and PI on energetic and control parameter

Indices	PU	H-flight	V-rep	CVE	CVS
BMI	4%	2%	3%	0,8%	1,4%
Significance F	0,53>0,43	0,61>0,27	0,56>0,35	0,77>0,08	0,7>0,15
PI	3,75%	3%	3%	0,9%	2,3%
Significance F	0,54>0,38	0,58>0,31	0,58>0,31	0,76>0,09	0,63>0,24

Another achievement consists of an interface (fig. 2.34) that enables reports generation at the end of the test, and, most important, the interpretation of results.

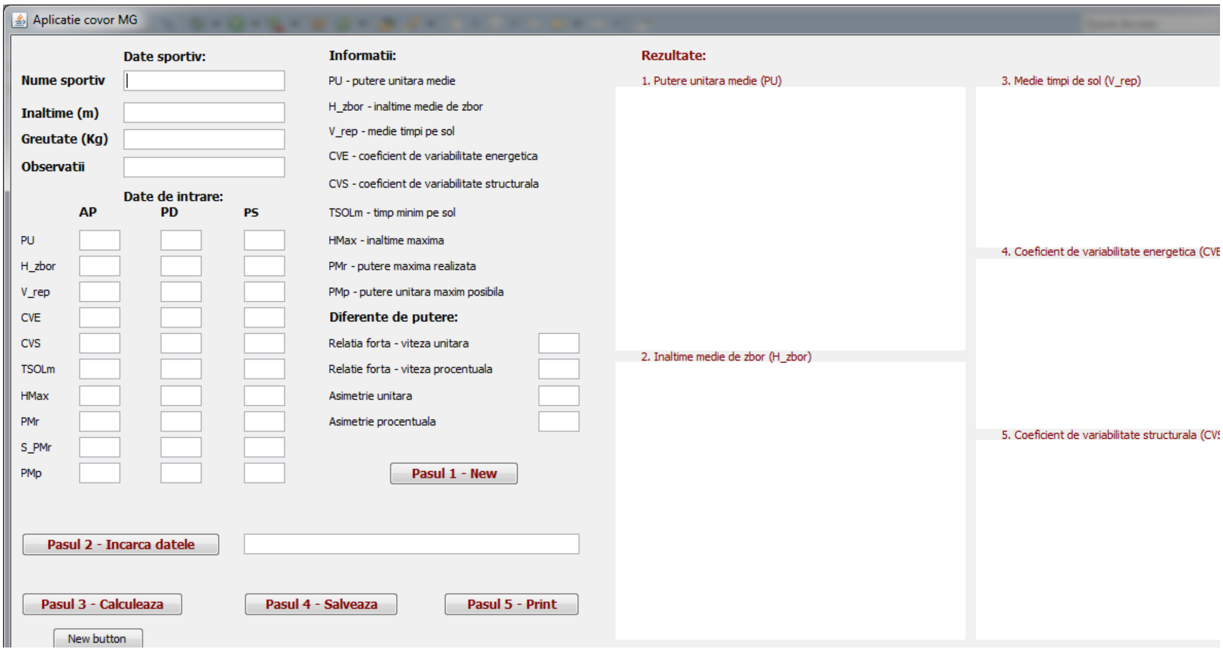


Fig. 2.34 – MGM interface

CHAPTER 3

Biomechanical study using the kinect sensors

The Kinect sensor is a depth camera that can be used for assessing full – body movements in terms of joint and/or segment positions and movement geometries. The functionality of the equipment has been highly debated in many studies wherefrom result that the depth camera in question is accurate and reliable in studies such as human biomechanics.

A biomechanical study can be oriented trough objectives such as human body performance, rehabilitation and pathologies.

Therefore the Kinect sensor has become an uptrend being used to study the biomechanics of the human body by detecting the subject without fluorescent markers through 3D scanning (Ackermann , Schiehlen, 2006), in 3D reconstruction and 3D description of trajectories.

Do to the easiness of interaction with the subject, because it is very affordable and is not as robust as specialized systems, this hardware is an upward trend, being used in the study of human's biomechanics (Ganea, 2012) using detection of subjects without fluorescent markers (Schwarz, 2012) by 3D scanning, 3D reconstruction and 3D description of trajectories (Zhang, 2011).

Human gait analysis is the first application of this device (Ganea, Mereuta et al. 2013). Human locomotion is a synchronized interaction of many subsystems like skeletal, muscular, neural etc., which make up the human body. Theoretically, this motion can be defined as an alternating motion, nearly sinusoidal, of the kinematic elements. This cyclical motion can be impaired by various factors that define the human body. For this purpose a kinematic analysis of the human lower limb during normal and pathological gait was performed.

In order to assess the symmetries and asymmetries of the human locomotion we have developed a system (fig.3.1.) aimed to study the motion geometry based on the following components:

System components and their role	
A. control monitor;	The monitor role is to help the subject to become aware of the movement and to normalize the movement.
B. processing unit;	The processing unit is represented by a laptop which connects the Kinect sensor and the control monitor. The main role is to offer processing and computing solutions to the system.
C. tripod;	The tripod is used for adjusting the distance from the camera to the ground so that the sensor can obtain the maximum visual space
D. depth camera;	The depth camera in use is a Kinect sensor. This sensor is based on a color camera and a depth camera (fig.3.2). The depth camera sends a patent of light through an IR emitter (fig.3.3). The reflected pixels are perceived by the IR receiver, and the new developed image, which contains information relating to the distance of the surfaces of scene objects from a viewpoint, is

	formed. The reflected pixels are perceived by the IR receiver, and the new developed image, which contains information relating to the distance of the surfaces of scene objects from a viewpoint, is formed.
E. Application.	The application is a script developed in C# that uses the libraries from Microsoft. The role of this application is to distinguish the subject in the depth image (fig.3.4), to track the subject (fig.3.5) and to reconstruct the kinematic chain of the human body, determining thereby the positions of 24 points and joints (fig. 3.6).

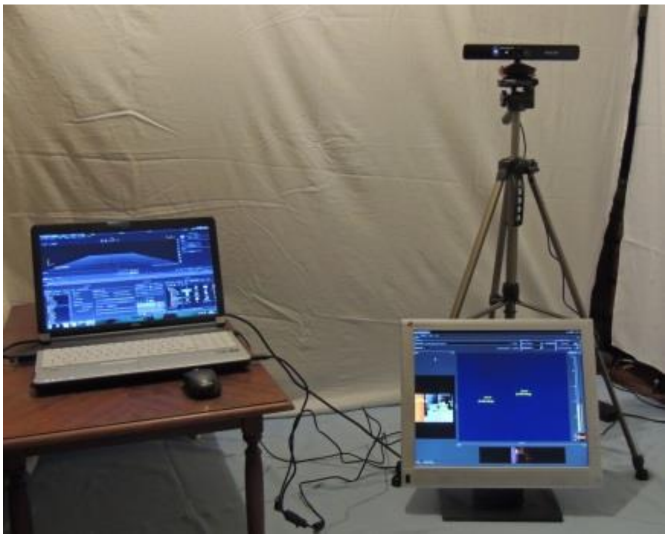


Fig. 3.1 The analysis system

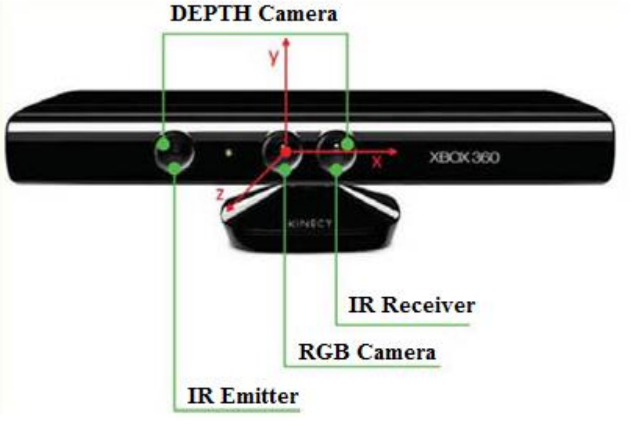


Fig. 3.2 Kinect sensor

Fig 3.3 The construction of the depth image

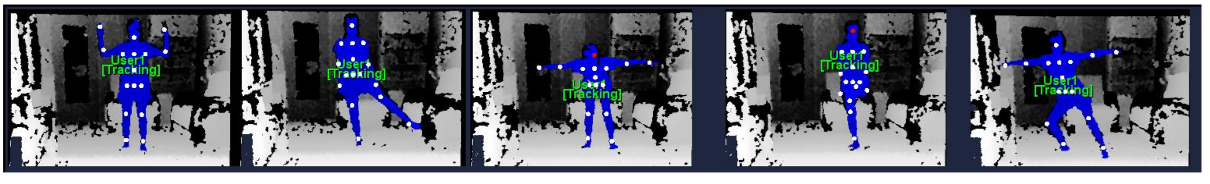


Fig. 3.4 The subject depth image

Fig. 3.5 Subject tracking

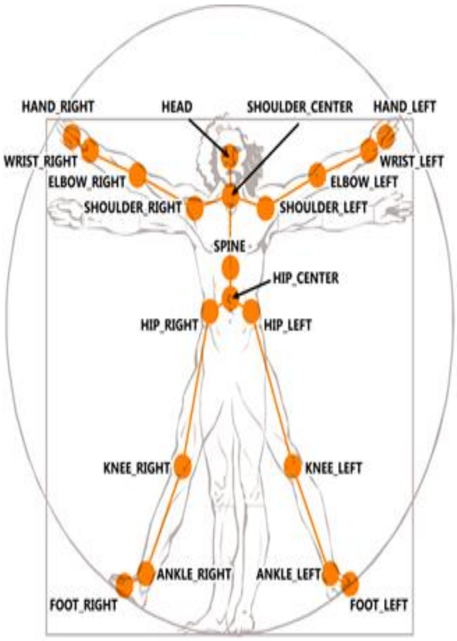


Fig. 3.6 The joints position generated by the Kinect sensor

During the experiment, the subject performed 9 gait cycles. The first 3 gait cycles were performed to evaluate the symmetries of the human locomotion, and the last 6 aimed to determine if the developed system is able to distinguish the asymmetries during human locomotion. The output data revealed that, even if the subject attempted to normalize the locomotion phases, the three pairs of gait cycles varied. During normal gait (fig.3.7), a relative symmetry can be observed, at the beginning stage of the experiments.

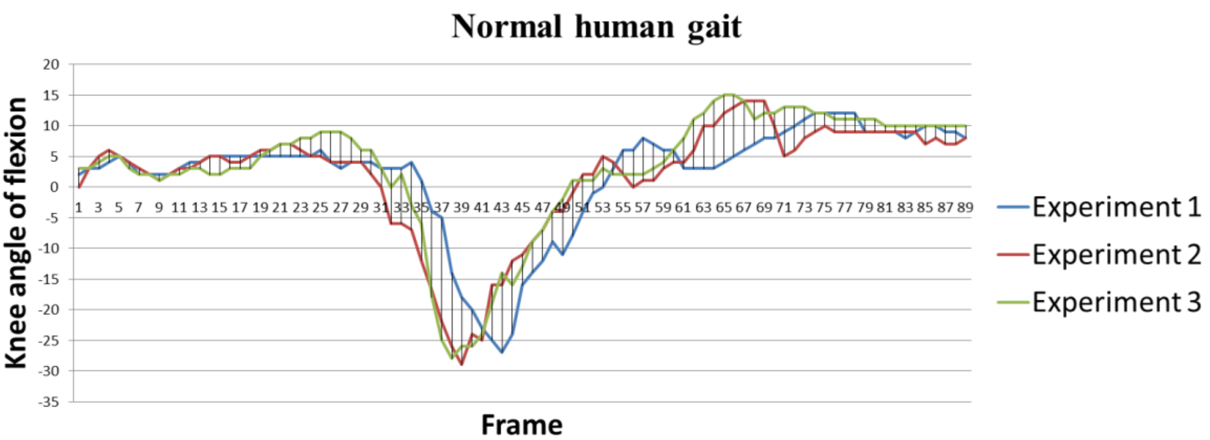


Fig. 3.7 Time variation of the flexion knee angle during normal human gait

During the human pathological gait it can be observed a pronounced asymmetry during gait phases (fig. 3.8, 3.9).

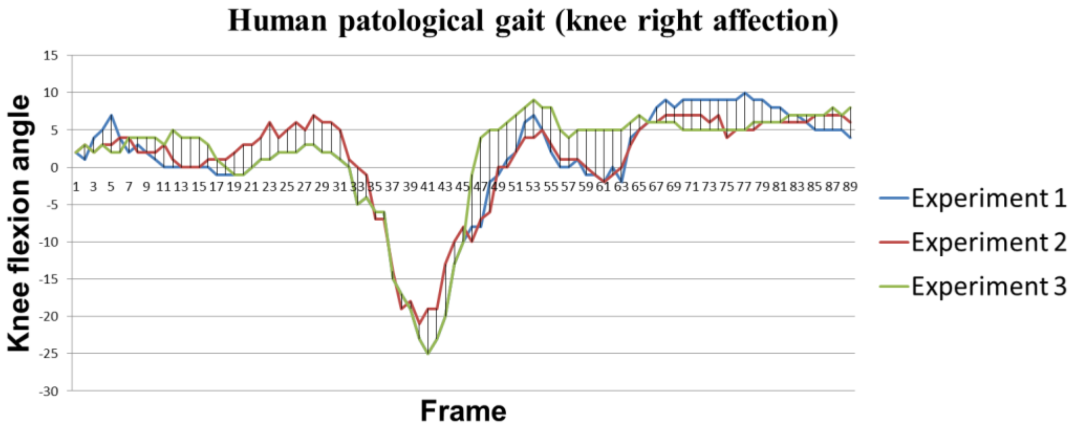


Fig. 3.8 Time variation of the flexion knee angle during pathological human gait (right leg)

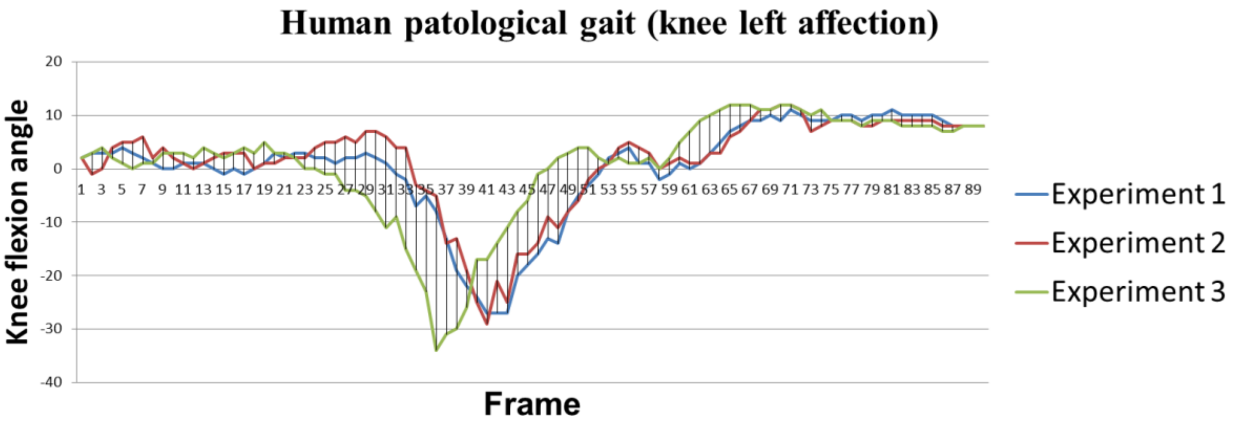


Fig. 3.9 Time variation of the flexion knee angle during pathological human gait (left leg)

The data revealed that the developed system is capable to distinguish the symmetries and asymmetries during human locomotion. Modifying systematically the length of the human lower limbs kinematic chains by 3 cm, the system was able to show an angle variation by $\pm 6^0$ of the left knee flexion.

We have also used the kinect sensor to assess the vertical posture of athletes (Ganea, Mereuta et al. 2013). In order to achieve that gaol the data collected from kinect sensor were used to establish the deviation of the body from the standard vertical position.

The protocol requires performing jumping under the following conditions:

1. without looking at the control monitor (experiments A1, A2 and A3);
2. looking at the control monitor (experiments B1, B2 and B3);
3. blindfolded (experiments C1, C2 and C3).

Three types of jumping were performed:

1. 3x15 jumps on both legs (experiments A1, B1 and C1);
2. 3x15 jumps on right leg (experiments A2, B2 and C2);
3. 3x15 jumps on left leg (experiments A3, B3 and C3).

The vertical jumping was chosen because this is a complex action characterized by harmonized coordination of the body's kinematic segments like pelvis, thighs, shanks and feet and lower limb muscle and articular systems during push-off of center of mass, then for flight and last for landing (Kazennikov, 2012). During the first phase of vertical jumping (push-off) the jumper's center of mass must have the projection into the supporting polygon formed by de the feet (Filho A.C de Pina., 2007).

The most important criteria for an efficient jump is the height of the jump that is proportional to the detachment velocity of center of mass, followed by maintaining the flight balance which is directly related to the length of kinematic elements and muscle's forces.

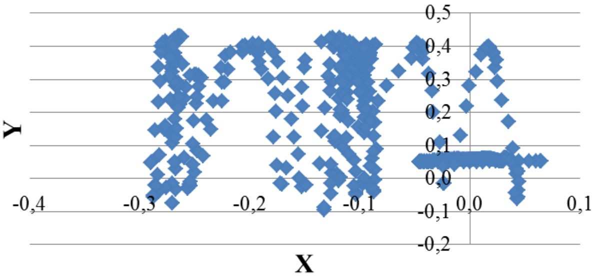
The task of the muscles during all vertical jump phases, besides maintaining the balance, is to accelerate the body's center of gravity up in the vertical direction to the extended body position.

To be reliable, the main condition of the experiment was that the group of athletes performs the set of vertical jumps, in orthostatic position. The study aimed to see if the projection of the center of gravity is within the sustainable polygon formed by the feet.

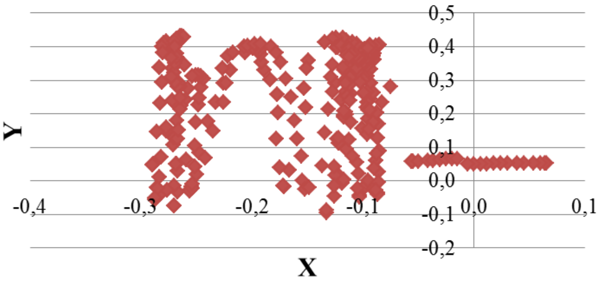
Another requirement of the experiment was that vertical jumps reached their maximum height, with full hip and knee flexion. Thus, the center of gravity reached its maximum height.

The role of this application is to initialize the sensor to retrieve process and analyze the center of mass projection on the transversal plane. A tailor-made application was developed. The role of this application is to initialize the sensor to retrieve process and analyze the center of mass projection on the transversal plane. In order to analyze the vertical posture of the athletes, the projection of hip central point in the transversal plane (xOy plane) was tracked. This is considered to be the human centre of gravity and a reference point in the kinematic analysis system.

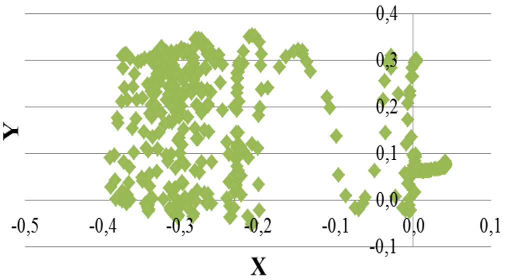
While performing vertical jumps on both legs, on right leg and on left leg with wide open eyes, it is noticed that the projection of center of mass is mainly situated on the left side of the subject (fig. 3.10), and the projection of center of mass describes a surface quite similar.



a) Both legs



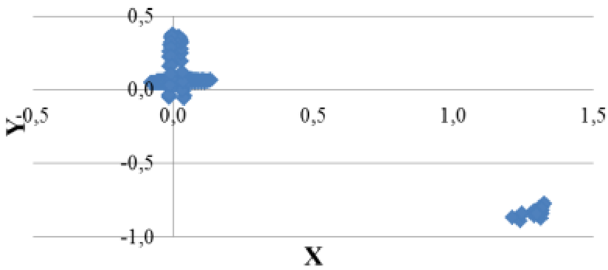
b) Right leg



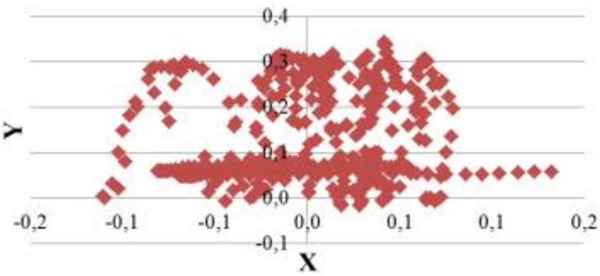
c) Left leg

Fig. 3.10 Projection on transversal plane of center of mass during wide open eyes vertical jumps (participant 1)

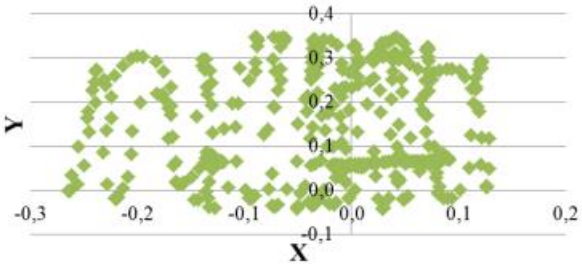
During experiment B it can be observed that the projection of the centre of gravity on the transversal plane is distributed on both negative and positive domains of x axis (fig. 3.11). This symmetry centered on a small surface is due to the fact the subject could follow his action on the control monitor. This means that the vertical posture can be reached and maintained with precision when the subject is able to follow his action.



a) Both legs



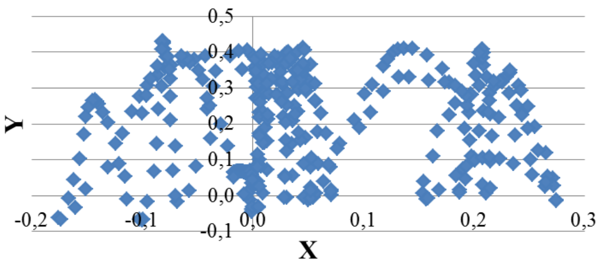
b) Right leg



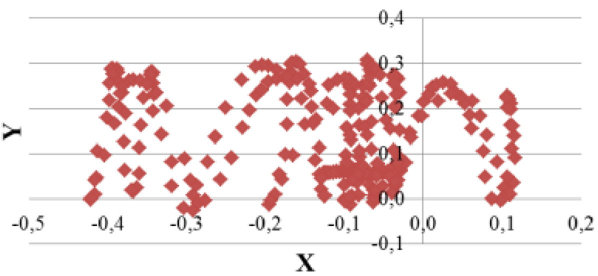
c) Left leg

Fig.3.11 Projection on transversal plane of center of gravity during vertical jumps while watching the control monitor (participant 1)

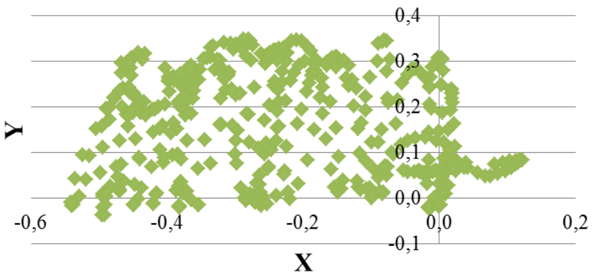
During experiment C, the distribution on the transversal plane of the projections of center of gravity is more spread relatively to experiment A. Due to the fact that the subject was blindfolded, the projection of center of gravity on the transversal plane is widespread, in both negative and positive domains of x axis and y axis (fig. 3.12).



a) Both legs



b) Right leg



c) Left leg

Fig.3.12 Projection on transversal plane of center of gravity during blidfolded vertical jumps (participant 1)

Experiment C has proved that due to the lack of perception of the surrounding space, the subject was not able to synchronize the lower limb dynamic system and therefore the phases of the vertical jumps. The results revealed that the group of athletes had maintained their vertical position during vertical jumping when they were able to visualize their actions on the control monitor. In this case the deviations from the origin of the reference system are relatively symmetrical.

The results demonstrate that maintaining the vertical posture is achieved through a complex mechanism that involves the interaction of lower limb muscle activity with vestibular, somatic and visual analyzers. The visual perception plays a crucial role in maintaining the vertical posture as proved by the results from experiment B. All data reveal the fact that if both legs are involved in all 3 phases of vertical jumping, the projection of the center of pressure on the transversal plane is more symmetrical.

The shift of weight on one leg leads to an asymmetrical projection of center of mass and a lower coordination. This is due to fact that the leg which maintains the weight of the body becomes responsible to the push-off and landing phase while the other leg has to maintain the balance during the flight.

The results also revealed the fact that the proposed system with a Kinect sensor was able to accurately retrieve the information from the scene. The best vertical posture was attained when the subject performed the vertical jumps on both legs during experiment B.

CHAPTER 4

Modeling the upper and lower limbs. Assessing the magnitude of muscle forces.

Another area of interest is related to modeling the upper and lower limbs and to determine the magnitude of forces developed in muscles.

The author is member of a multidisciplinary research team involved in studying human biomechanics. Thus, we have managed to develop virtual models for upper limb and lower limb aiming to analyze the active space, to express the forces and to determine the kinematics. Knowledge of mechanics and the behaviour of the musculoskeletal system is a prerequisite to designing systems to assist persons with disabilities, such as pros-theses, orthosis and neuro - prostheses.

To this end we have considered the limbs as spatial mechanical structures. We have been able to show the angles, the angular velocities, the angular accelerations for different input motions suitable to reveal the activity of the most important muscles of the human upper and lower limbs.

In order to create the kinematic model of human upper limb the environmental modelling program named CATIA was used (Mereuta, Tudoran, 2013). The kinematic model of the linkage which simulates the movement of the upper limb consists of five constraints and four kinematic elements (Tudoran, 2013) (fig. 4.1).The shoulder is modelled using two rotational joints (Drăgulescu, 2005). The rotational axes of joints are orthogonal. The following motions are allowed: abduction -adduction motion of the arm (joint A); flexion-extension motion of the arm is (joint B).

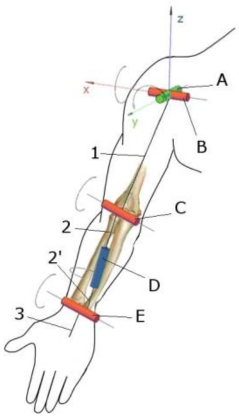


Fig. 4.1 Kinematic model of the human upper limb

Fig. 4.2 Anatomical model- arm muscles

The biomechanical model of the human upper limb comprises six muscle fibres (fig. 4.2) corresponding to the brachial muscle, with long and short head of the brachial biceps muscle, medial, lateral and long head of the brachial triceps muscle.

In order to perform the kinematic analysis of biomechanical model of upper limb the the following motions have been chosen: the flexion of the forearm and the push-up. The flexion of the forearm highlights the brachial and biceps muscle activity, while the push-up emphasizes the triceps muscle activity. The spatial end-effector motion emphasizes the kinematic behavior of the centres of gravity of the segments composing the skeleton of the upper limb.

The flexion motion consists of forearm motion within the range 0^0-90^0 (fig. 4. 3). The initial position of the forearm during flexion is the palm facing forward.

For the kinematic analysis of triceps – long, lateral and medial head, the law of motion has been chosen to match the push-up motion (fig. 4. 4).

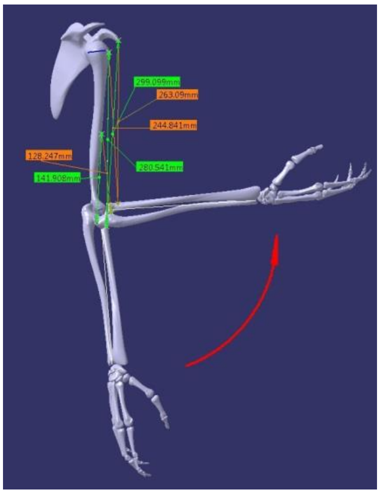


Fig. 4. 3. Forearm flexion

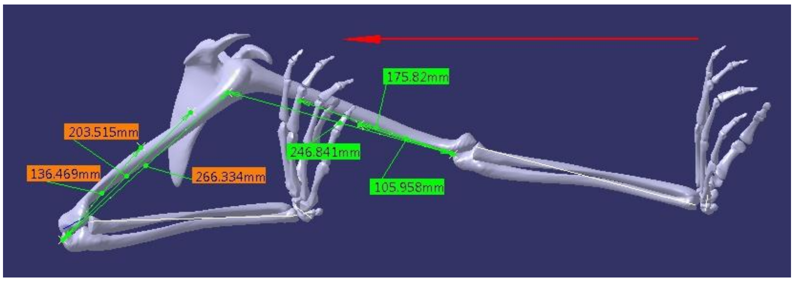
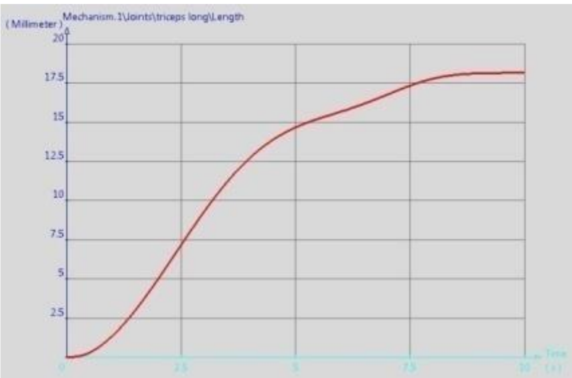


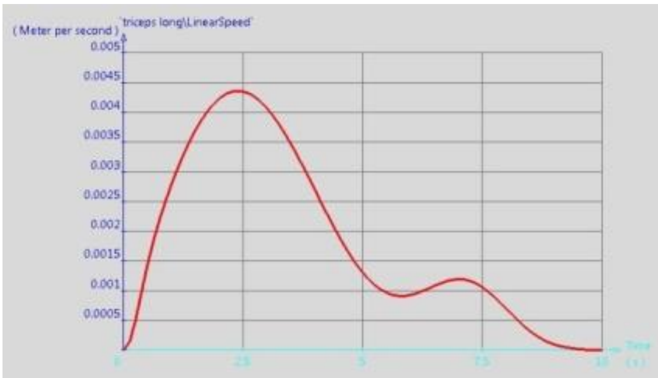
Fig. 4. 4. Push-up motion

During the push-up motion three of the triceps muscle fibers are lengthening. The time variation of these lengthens is shaped the same for the lateral and medial head, but the values are different.

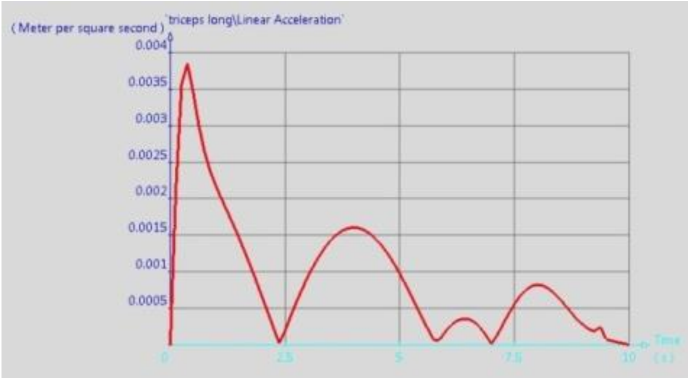
The shape of the lengthening curve of the triceps long head (fig. 4.5) is different from the other two fibers curve shape (lateral and medial), featuring an extended stretch since the insertion point of this fiber is on scapula and not on the humerus as in the case of the other two.



a) Legthening



b) Velocity



c) Acceleration

Fig. 4.5. Long head triceps

The kinematic model provides information about displacements, velocities and accelerations of bone segments composing the skeleton of the upper limb. This information can be used as input in the design of orthotic devices. So the most relevant conclusions are:

The brachial muscle has a slightly different behaviour than the biceps (long and short head) due to the fact that the input position is corresponding to the situation in which the forearm bones are prolonged to the arm bone and not in orthostatic position.

The forearm flexion stresses especially the long head and the short head of the biceps compared to the brachial muscle. To stress only the brachial muscle, either during medical rehabilitation programmes, either during sports training, the flexion should be in the range of 0°-2.53° flexion of the forearm.

The push-up motion stresses the triceps medial head muscle compared to the other two fibres of the same muscles. To stress only the triceps long head, both in medical rehabilitation programs, and in sports training the push-up must be in the range of 380-450 mm sliding along Oy axis of end effector.

The proposed kinematic model is highly complex and allows the simulation of different and complex motions.

Modeling the muscles has been a constant aim of researchers in biomechanics (Mereuta, Tudoran, 2013). They have desired either to anticipate the muscles behaviour under certain conditions, or to describe how they work and estimate the force that they develop. The planar models developed by Huijing and Woittiez (1984), have proved to be good enough for estimating the effect of muscle fibres slope on the force they develop. If we intend to use the muscle model for estimating the neuro-muscular control, we have to find out the link between the force they develop and their lengths or the contraction velocity (Winters, Stark, 1985). Finite element models are useful when interaction between muscle fibres is taking into account (Linden 1998).

Basically, muscle models may be grouped into two categories: Hill-type models, which describe muscle functioning at macroscopic level using empirical relationships (Hill, 1938), however confirmed by experiments, and advanced models that explain their behavior at level (Winters, Stark, 1987). A very simple model of muscle can be the result of surface observations and investigations and may lead to a reaction of the system other than the real. A too complex muscle model may lead to failure to achieve the expected results, owing to the large number of details.

Estimation of a muscle force can be achieved using a muscle model and experimental measurements EMG (electromyography) type (Lloyd, Besier, 2003). The method is not al-ways effective because there are 38 muscles, and most of them are either small or are overlapping and their detachment in order to estimate the force developed is virtually impossible. The Hill's model renders the possibility to estimate the force developed by the muscles, based on muscle contraction, respectively, on the muscle shortening/lengthening and on the contraction/stretching velocity. The muscle force - length curves (Chalfoun et al. 2005) highlight the fact that it is extremely important to know the length of the muscle fibre and optimal length of the fibre. The muscle force is the sum of active and passive force (fig. 4.6).

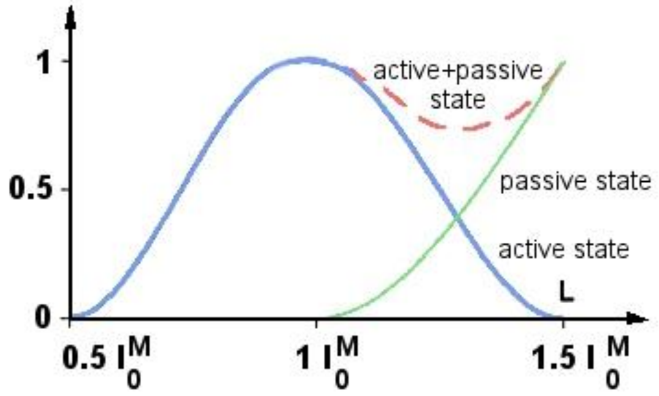
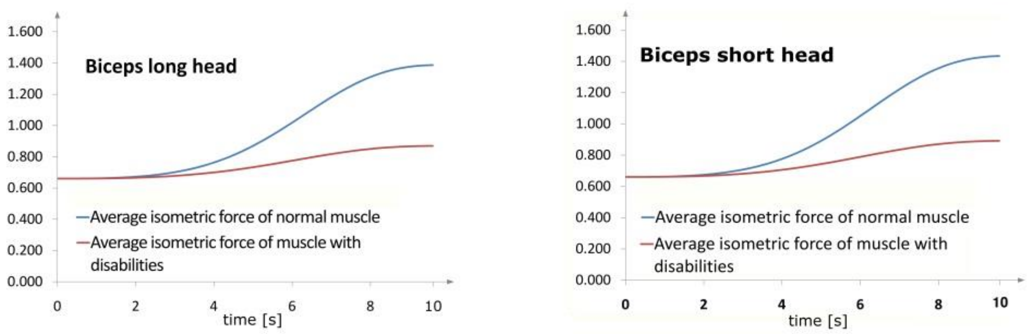
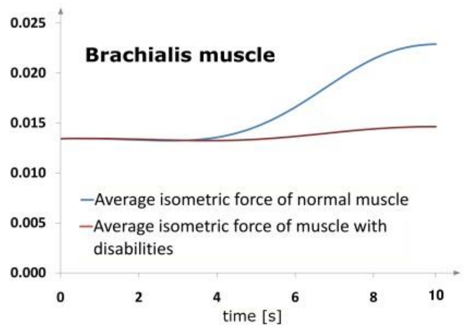


Fig. 4.6. The force-length relation (active/passive state)

The kinematic model of the upper limb allows the estimation of the most important muscles forces, because the motion simulation has provided the length variation of the muscle fibre and thus, using data and formulas from literature we were able to assess its time variation, as well as its dependency on the contraction velocity of the muscle. We are now able to compare the motions for a normal upper limb to those of a disabled one. Thus, considering the upper limb flexion, we have found that the muscles biceps long head, short head and brachial develops higher average forces (fig. 4.7) for a person who can perform the full motion (90^0) versus a person with disabilities (45^0).



a) biceps long head; b) biceps short head



c) brachialis

Fig. 4.7 Average isometric force

The kinematic model is able to provide the kinematic parameters that describe the motion and the average forces developed by the most important muscles of the upper limb. The brachial muscle force can be assessed only using biomechanical models. Experimental measurement of this muscle activity using EMG cannot be done using non-invasive methods. Therefore, the kinematic model is an alternative to such invasive procedures. The muscle forces and their time variations are input data in dynamic models of the human upper limb. Starting from the average force, it is possible to determine the force magnitude, based on the maximum developed muscles force from literature.

A dynamic model was also created for estimating the magnitude of reaction forces and moments in the shoulder joint of the human upper limb (Mereuta, Ganea, et al. 2014). Injuries of shoulder joint consist sometimes of traumatic ruptures. Most traumatic injuries of the shoulder joint are resulting from extensive degenerative changes caused by stress of mechanical factors influencing this anatomical structure. All these changes particularly affect individuals who practice labors or sports involving repeated rising of the arm above the head or extended abduction.

These strong mechanical stresses determine high reactive moments and forces in the shoulder joint. So it is important to know their magnitude. The simulation method renders the forces and moments in the shoulder joint and it was proved that they have different values depending on external applied forces and moments. The proposed method can be generalized if the solid model of the human upper limb is parameterized. Thus, theoretically it is possible to achieve the simulation of any upper limb. The simulation model have used the muscle forces as input forces, and their magnitude was assessed using Hill’s model based on the connection between the magnitude of muscle force, its contraction velocity and its cross section. The reaction forces and moments are also important for designing the exoskeleton as an external structural mechanism with joints and links corresponding to those of the human body.

Considering that the flexion-extension motion of the forearm is simulated under three different conditions, the reaction forces and moments are determined. The first actuating case is corresponding to the case in which the driving force is acting on the long end of the biceps muscle. In the second case the driving force is acting on the short end of the biceps muscle, and in the third case the driving force is acting on both ends of the biceps muscle.

The first two simulating conditions correspond to the possible situations in which human upper limb is suffering from some muscles dysfunctions.

For example, in the third actuating case, due to the fact that there are two driving forces, the time variation curve of the reaction forces arising in the shoulder joint has a sharp decreasing at the beginning of the motion, from the magnitude of 3.4 Nmm, followed by an arched shape with a maximum value of 1.8 Nmm (fig. 4.8a).

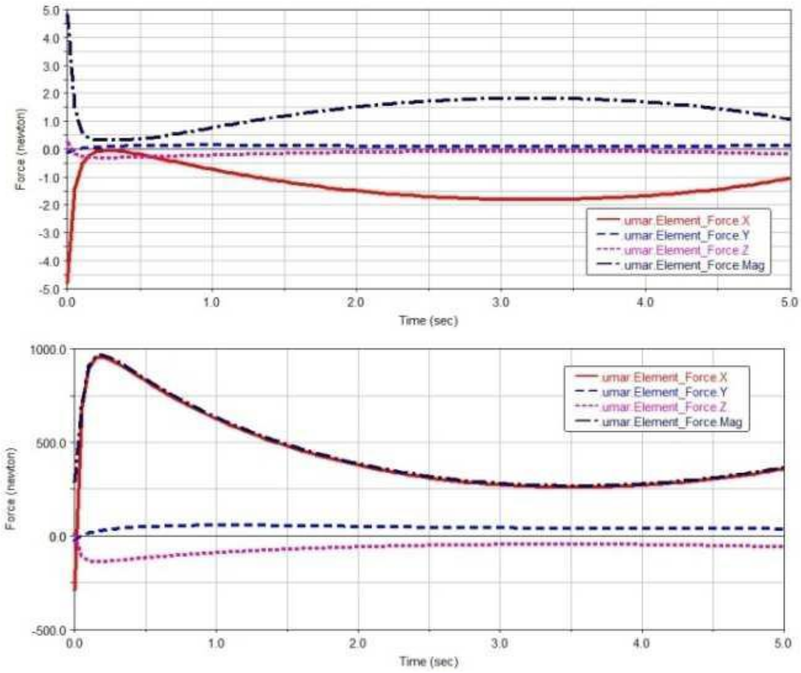


Fig. 4.8 The reaction forces of the shoulder (a. without external force, b. under 10kgf)

In the second loading case the variation curve presents a sharp decreasing of amplitude from 616.4 Nmm, followed by an arched form reaching a minimum value 267.2 Nmm (fig. 4.8b). The variation curves of the reaction moments occurring in the shoulder joint has a curved form with a maximum of 90.2 Nmm (fig. 4.9a), in the first loading case, and in the second loading case the curve reaches a minimum value of 1581.9 Nmm (fig. 4. 9b).

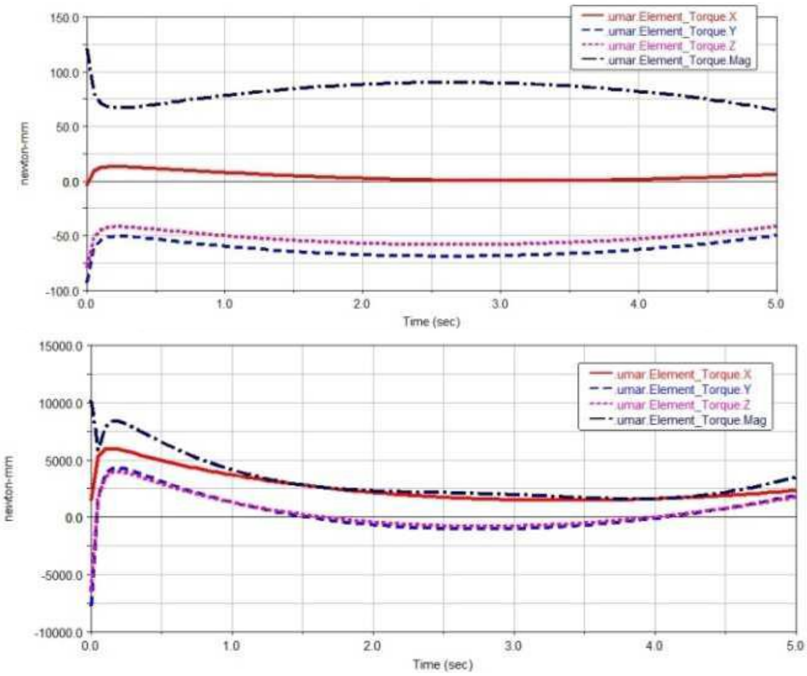
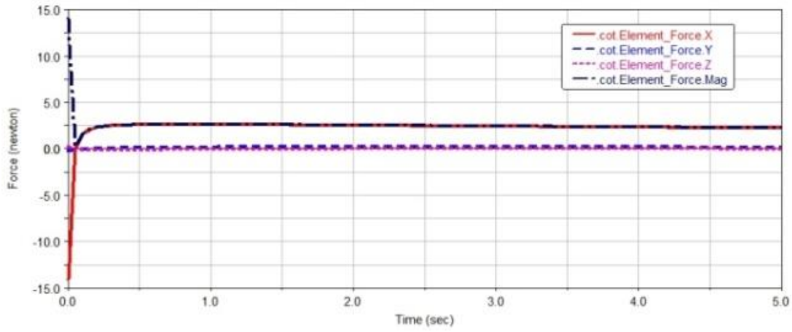


Fig. 4.9 The reaction moments of the shoulder (a. without external force, b. under 10kgf)

The same analysis can be performed on the elbow joint, thus obtaining the reaction forces and the torques in different loading cases. For the first loading case the elbow reaction force sharply increases up to 13.9 N, then slowly decreases from 2.6 N to 2.2 N (fig. 4.10a). In the second loading case the curve rises sharply to 3777.1 N and then slowly decreases from 873.5 N to 541.4 N (fig. 4.10b).



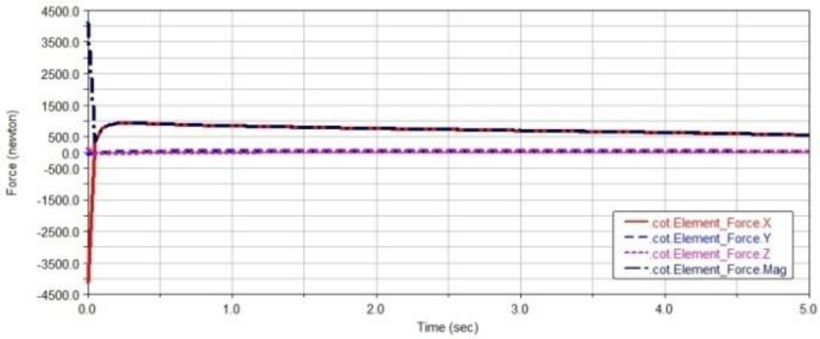
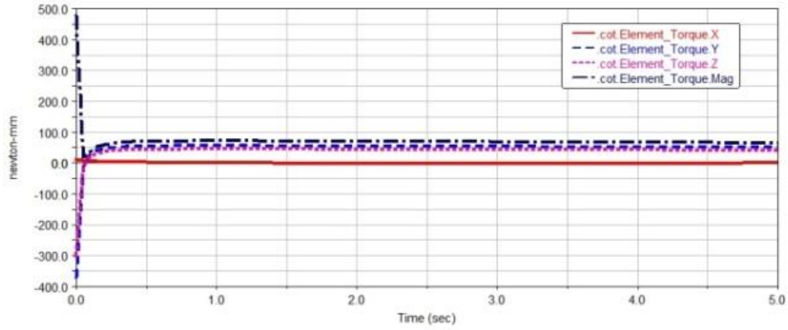


Fig. 4.10 Elbow joint reaction forces (a. without external force, b. under 10kgf)

The time variation of the elbow reaction torques presents a sharp drop by 459.3 Nmm followed by a smooth decrease from 71.3 Nmm to 65.7 Nmm for the first loading case (fig. 4.11a). For the second loading case the shock magnitude is 132611 Nmm, lasting 0.05 seconds, followed by a smooth decrease from 26084.4 Nmm to 15591.5 Nmm registered at the end of the simulation (fig. 4.11b).



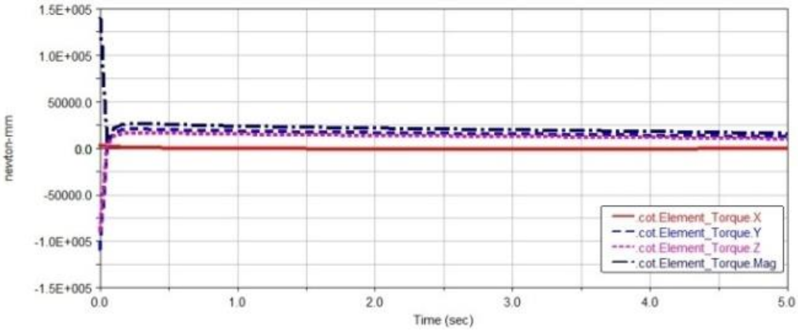


Fig. 4.11 Elbow joint reaction torques (a. without external force, b. under 10kgf)

Using methods and techniques for multi-body modelling with optimization techniques it is possible to evaluate the magnitude of reaction forces and torques in human upper limb joints, it is possible to analyze complex models, so facilitating both the simulation and the interpretation of the results.

Modifying the magnitude of the loads, we can observe the differences in joints reaction forces and torques from one loading case to another. It is important to be aware of the stresses to which the joints are subjected in order to plan training programs for improving the performances or to design devices that might assist a disabled person. The experimental results have revealed that there is an important stress of the elbow joint at the beginning of each motion, considered to be a shock comparative to the following stages of the motion.

Some experimental research regarding the activity of muscles during the flexion extension motion of the human upper limb was also conducted. The experiment involves electromyography (EMG) as a noninvasive method. So, the EMG analysis can provide a tool for estimating muscle activity and together with a muscle model, the force developed by the muscle can be much better estimated and the stages of muscular activity are better highlighted.

The technical instrumentation used in the experiment is the BIOPAC system (fig. 4.12), consisting of:

A. Computer with AcqKnowledge program. AcqKnowledge is the software component of BIOPAC acquisition system and is an interactive and intuitive way to view, measure, analyze and transform data. The main functions AcqKnowledge can perform are:

a) monitoring data acquisition, i.e. establishing the recording channels, calibration, setting the analogue/digital acquisition and conversion parameters, defining the mathematical functions for on-line processing of waveforms;
b) storing and handling data in the computer;
c) discrete signal processing after registration, i.e. mathematical, analytical functions, frequency analysis, filtering, statistical functions;
d) accessing a proper editor (journal), this allows marking some comments specific to a set of records.

B. BIOPAC MP150 data acquisition (A) station. The component MP150 (fig.1) is the central unit of the experimental data acquisition. This component retrieves the signal from the external drive which is the EMG100C module, processes it and then forwards it to the computer.

C. STM100C stimulating module (B), which is used to filter the signal.

D. UIM100C signal amplifier (C) links the external modules, meaning the EMG100C and MP150 acquisition unit. The module is the input interface for pre-amplified signal and / or digital signal for the MP acquisition unit. It also offers a direct path between analogue or digital channels 0/1, and MP device when acquiring or transmitting data to external equipment.
E. EMG100C external mode (D) for data acquisition which amplifies bio-electric potential characterizing the activity of skeletal and striated muscles.
F. Cables LEAD108 and LEAD110S-R;
G. Modular Extension Cord MEC111C;
H. EL503 sensors.

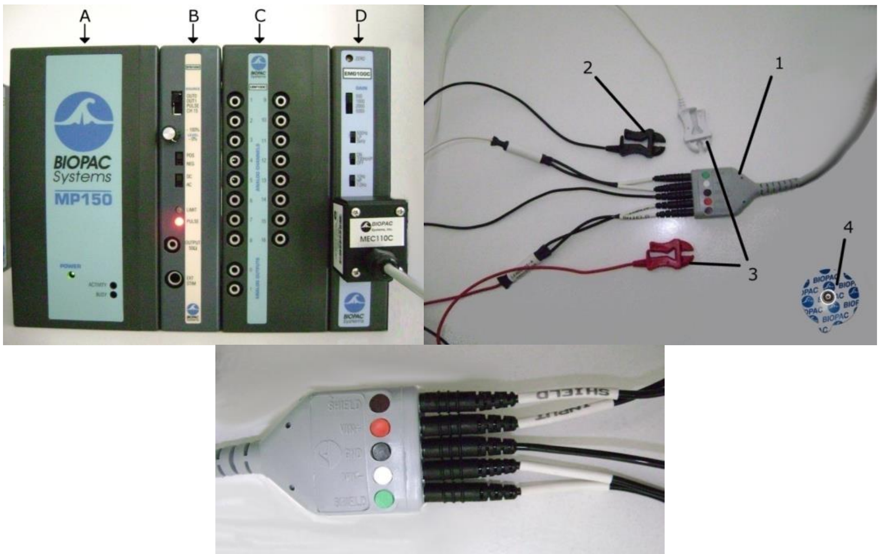


Fig. 4.12. BIOPAC system

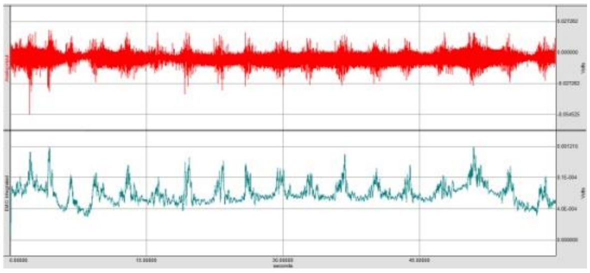
The experiment was conducted under three loading conditions (fig. 4.13):

a) No loading, just the weight of the forearm and hand;
b) Loading the subject with 2kg weight (only dumbbell bar);
c) Loading the subject with 5kg weight.

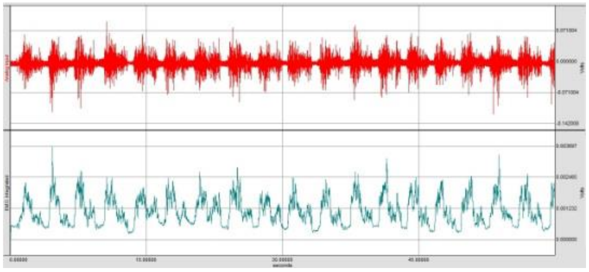
Fig. 4.13. Experiment snapshots

For each loading condition, the experiment duration is 60 seconds, during which 18 flexion-extension repetitions were performed. Corresponding to these three loading conditions three recordings of muscle activity were obtained (fig. 4.14).

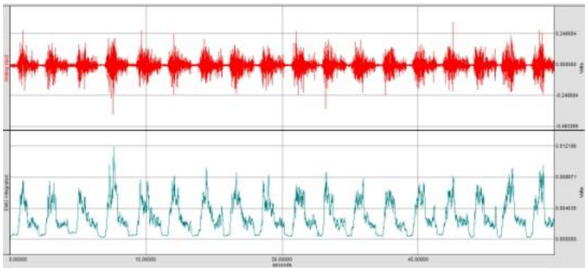
The red signal signifies the raw EMG signal and blue one is the processed signal. Signal processing is carried out by integration, eliminating the noise.



a) first loading case



b) second loading case



c) third loading case

Fig. 4.14 EMG signal

We can conclude that when the spectrum of muscle activity is known, it can provide its deployment and time and vice versa.

The following phases of muscle activity are shown in fig. 4.15:

1. Inactivity phase - the muscle has no activity and is able to relax;
2. Loading phase - muscle develop the work to defeat the weight. In this phase the muscle performs isotonic-concentric contraction;
3. Maintenance phase – the muscle develop the necessary work to maintain the weight position. In this phase the muscle performs isometric contraction;
4. Primary discharge phase – the muscle performs isotonic eccentric contraction;
5. Motion stabilization phase - in this phase the muscle develops supplementary effort to provide precision to motion. Although this phase has a constant stage, however, due to the elastic properties of muscle and tendons, no mechanical shocks arise. The muscle activity presents is isometric but, slightly visible, due to muscle elasticity;
6. Secondary discharge phase - muscle contraction is isotonic, eccentric;
7. Phase of inactivity - muscles relax after exercise.

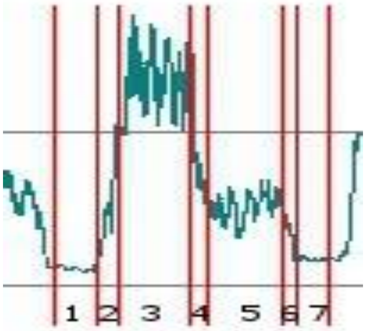


Fig. 4.15. Muscles contraction phases

The EMG analysis can provide a tool for estimating muscle activity and by combination with a muscle model, such as Hill's model (Lloyd, et al. 2003), the force developed by the muscle can be much better estimated and the stages of muscular activity are highlighted. A problem that still remains unsolved is related to the choice of those voluntary motions which allow the isolation of a certain muscle of the upper limb. A qualitative comparison of muscle activity between the solutions offered by the Hill and the EMG models can be a starting point for further analysis related to the forces developed by muscles and muscle action phases.

CHAPTER 5

LateraTEST –device for assessing laterality

6.1. State of art

Currently there are no devices or equipment used to test laterality, i.e. to determine the dominant position of a hemisphere brain function that causes inequality left and right halves of the body.

Most tests are based on observation, the execution of the daily activities or on questioning subjects. Sensory-motor asymmetry phenomenona has a strong hereditary conditioning, translated into specific functional organization of the cerebral hemispheres. For the right-handed there is a functional dominance of the left hemisphere and for the left-handed the right hemishere of the brain. Left handed can be educated to use his right hand, but the question is whether the benefits of such action outweigh the disadvantages that may occur.

All these manifestations are usually called the opposite of laterality (Ciucurel, Ciucurel, 2002). The laterality opposite phenomena is relatively common in sports since most branches of sport necessarily require the development of sensory-motor skills for both dominant half and for the contralateral side.

The laterality issue has been studied by many authors, but there wasn't a way to estimate, to explaine or test it to be universally accepted. There are tests based on observation, tests based on questionnaires, exercises for laterality education like Ozeretski - Guillmain spatial orientation test - Piaget Head, Harris laterality test, laterality battery of Galifret Granjon (Lungu, Nicholas, 1991, Musu, Taflan, 1999, Verza, Green, 2000, Vlad, 1999, Vrasmas, 1999, Oprea, Riveting, Chiriacescu, Lungu, 2003).

Some authors have attempted to develop mathematical models to measure the intensity of the social and behavioral factors that affect laterality and to explain why right-handed dominance and superiority of left-handed athletes (Abrams, Panaggio, 2012, Garland, et al. 2009). However, these models have limitations since they reduce a complex adaptive system to a simple mathematical model in which many simplifying assumptions were adopted and empirical correction factors and coefficients were introduced.

Some authors (Laurens, Raymond, Faurie, 2009) attempt to explain possible mechanisms and consequences for the predilection of the left hand usage, showing hereditary factors, hormonal, cultural, and future trends of this polymorphism.

Because they didn't find a way to assess laterality, some authors have attempted to discover gene responsible for the dominance of cerebral hemispheres (Francks, et al., 2007, McManus, et al. 2009), others have tried to explain the link between laterality and cognitive development (Magat, Brown, 2009), and the advantages and disadvantages of asymmetry (Rogers, Zucca, Vallortigara, 2004, Vallortigara, Rogers, 2005), indicating that it is associated with an increased ability to perform two tasks at the same time.

Other authors have developed models based on the frequency of polymorphisms in relation to the use of the right hand or left hand (Billiards, Faurie, Raymond, 2005), or have used game theory to analyze the evolution of laterality (Ghirlanda, Vallortigara, 2004). They have also tried to establish a correlation between the cerebral hemispheres laterality and longevity (Halpern, Coren, 1988), as well as right-handed and left-handed differences in performing some usual movements (Hardie, Wright, 2014).

The author was able to design and make a mechatronic system for determining and improving the reaction rate and the dominance of cerebral hemispheres – named LateraTEST, in order to reduce imbalances between left and right laterality and increase the selective reaction rate to visual stimuli.

The mechatronic system consists of an experimental platform and software that runs on a personal computer (PC) or notebook. The connection between the platform and the computer is via a standard USB cable. The experimental platform includes:

1. A set of 13 smart buttons made specifically for this application. Each button contains a comeback contact (operated by touch), a light source with selectable intensity and color (red, green, blue or combinations thereof) and an electronic circuit that automatically turns off the light source when the button is pressed;
2. A mechanical structure for positioning and support for smart buttons. The support structure will form a regular octagon with apothem of 0.6m and smart buttons are placed according to a suitable schema;
3. An electronic circuit with microprocessor that connects the smart button and the software from the computer. The microprocessor contains a program taylor made for this application and performs the following functions:
    - allows multiple pre-programmed sets of exercises, some containing a fixed sequence (repeated) of buttons and colors, some with completely random order;
    - receives from the PC the code of the test to be run;
    - allows running offline exercises without connection to PC, for demonstration purposes, or as individual training or as game for heating;
    - activates a light source for each smart button;
    - measures the a reaction time since light activation to pressing the button;
    - disables the button and move to the next combination of button and light, if a button has not been pressed for 2.5secunde;
    - transmits the following information to the PC application, if the PC is connected: code button, the hue of light used and the reaction time measured in milliseconds.

The software running on the PC performs the following functions:

- allow identification of the participant, to maintain records of performances;
- allow the selection of a set of exercises which will be subject to the person involved;
- transmit to microprocessor on experimental platform the identification code for each chosen set of exercises;
- receive, interpret and summarize response times for each button separately;
- estimate the parameters of symmetry of the participant, based on the space position of smart buttons and the average response times for each button;
- display data from experimental platform in an intuitive form, easy to interpret.

The organization chart for the operation of the microcontroller application that runs on the experimental platform is shown in figure 5.1.

The software is a Java application that provides a user friendly graphical interface which will help determine the reaction time to visual stimuli of different frequencies and wavelengths.

The application is based on three major processes: preprocessing, serial communication and processing (fig. 5.2).

The PC application runs based on the flowchart shown in figure 5.3. Sequences * A - * B are detailed in figure 5.4.

The mechatronic system indirectly assess laterality measuring the speed of response to visual stimuli to the right and left upper limb, using several tests with white and colored light. The data collected are processed by specially designed software and the results are automatically generated in the form of status reports.

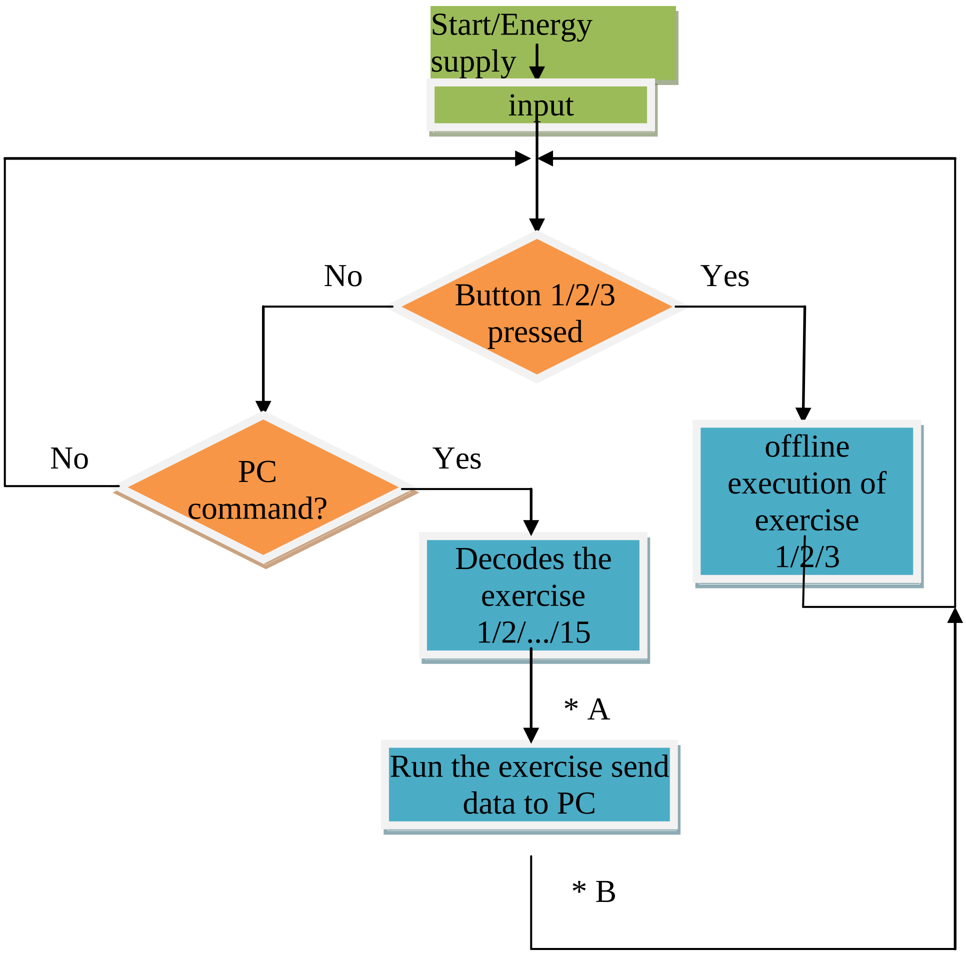


Fig. 5.1 Organization chart of microcontroller

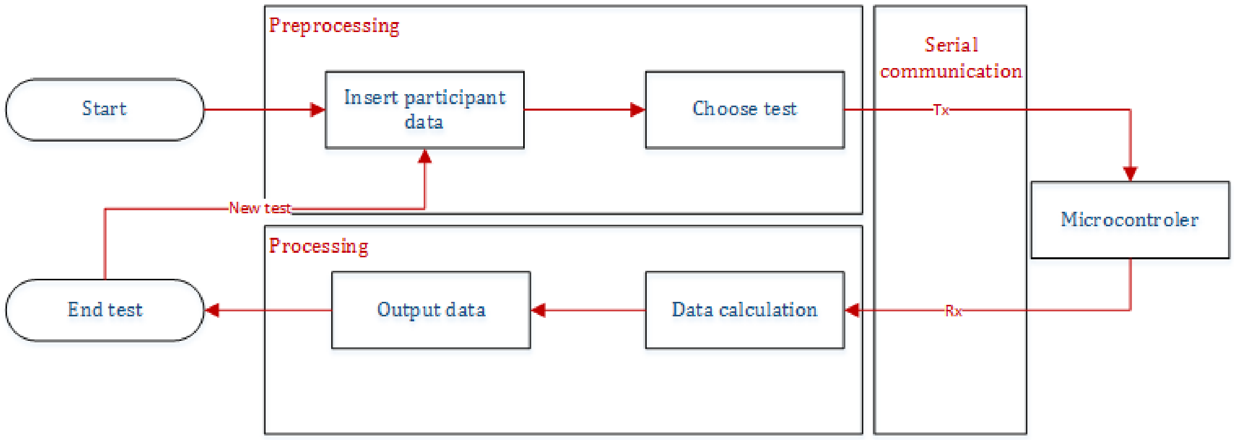


Fig. 5.2. – Major processes of PC application

Programs to improve performance, especially for athletes, people with slight disabilities caused by psychomotor disorders and children can be easyly designed.

The purpose of testing using mechatronic system is to reduce imbalances between the cerebral hemispheres, to increase the reaction speed to visual stimuli, increase the speed of selective response to stimuli of different colors.

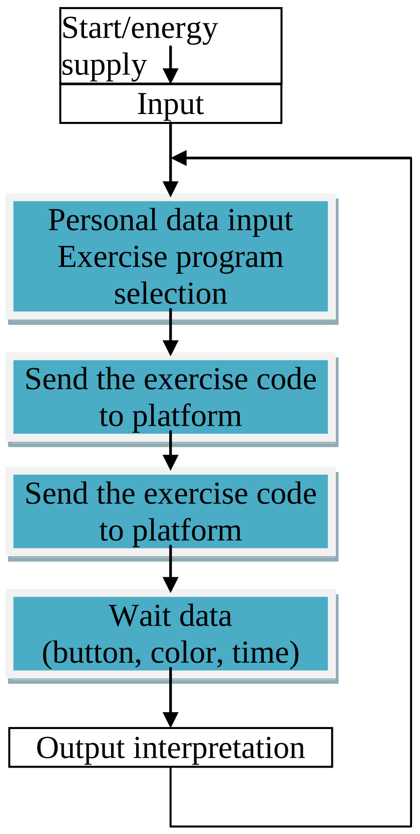


Fig. 5.3 PC application flowchart

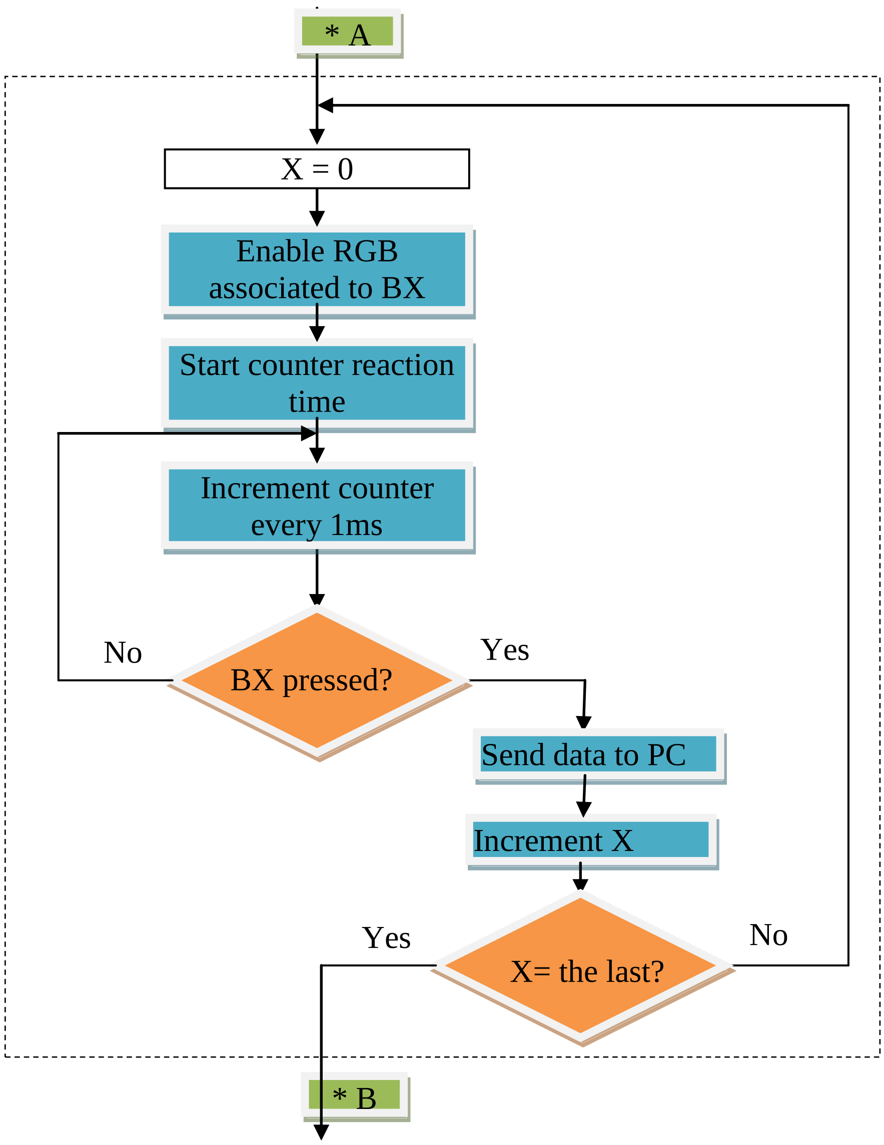


Fig. 5.4. A*-B* sequences flowchart

Several categories of athletes, children and people with neuro-motor deficiencies are targeted. How general population is right-handed, imbalances between the two hemispheres of the brain are widening and some activities controlled by nerve centers of a hemisphere can be executed more slowly or can not be performed simultaneously with other activities. The complexity of everyday life requires a softening of these imbalances, and therefore such a test is appropriate only if followed by an individualized training program.

For the athletes category different meanings on laterality are developed, but all of them take into account all the sports (Loffing, Soelter, Hagemann, 2014). Thus, it appears that some left-handed athletes are more advantaged during direct competition (i.e. boxing, sword, floret, tennis and table tennis etc.).

There are also sports at which being left-handed is an advantage (i.e. darts, snooker, golf). A clear division of sports in which being left-handed is an advantage can not be made. What is important is that the athlete reacts appropriately during competitions, anticipates the actions of opponents and takes decisions quickly. Therefore, it is important for athletes to develop their skills on both arms, thus being able to handle many tactical positions on the competition field, to adapt to specific situations during competition.

Regarding the group of children, laterality is manifested only after 5-6 years old, and skills can be educated and directed by game towards the efficient use of both arms and thus to the development of the two cerebral hemispheres and the stimulation of all areas of the cerebral cortex.

People with slight disabilities can attend training programs to increase the reaction rate by using LateraTEST.

A friendly interface (fig. 5.5) is also designed, so the system is easy to operate.

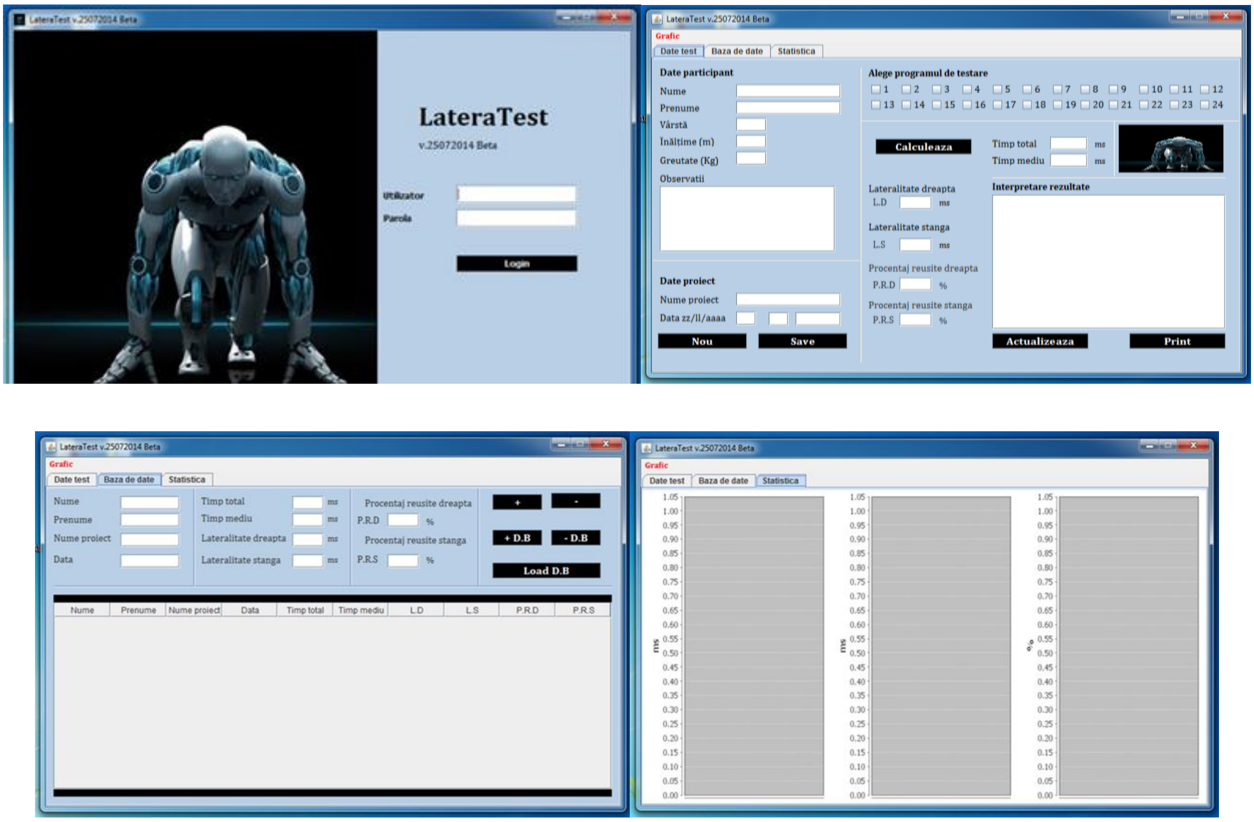


Fig. 5.5 LateraTEST Interface

The LateraTEST experimental platform was awarded the gold medal at the National Exhibition of Inventions UGAL-INVENT 2014. Figures 5.7-5.12 present the device and its details together with some intial tests on different subjects.

Fig. 5. 7 LateraTEST device

Fig. 5.8 – Instantaneous report

Fig. 5.9 – Testing the device

Fig. 5. 10 – Smart buttons

Fig. 5. 11 Electronic circuit

Fig. 5.12 – Interface and data acquisition

CHAPTER 6

Device for monitoring the athletic skills in real conditions

6.1. Device description

The device consists of an assembly - a pressure sensor and an electronic device which has direct utility data acquisition for the study of walking and running. The device aims at studying the running phases: the pole, the fall and the pull.

The device can be used in the detection of deficiencies in the accuracy of movements following the sync mismatch between the left foot and right one while running, differences in force between them, differences in pressure on soil, imbalances between force and velocity. All these considerations are based on essential running element, the main link, represented by impulse action of the foot on the ground.

Powerful sports brands like Adidas, Nike have build devices that survey the motor activity, providing information on changes in heart rate, distance running, etc. These brads provide also personalized training programs based on cardiac monitoring.

Their disadvantages are that all the data underlying the study and analysis of movements in the case of running and jumping is collected under strict laboratory conditions, sensors being attached to athletes using elastic cables, impending thus natural human motion.

The technical problem solved by thid device is that all the acquired data are collected in real conditions, starting with the terrain configuration and ending with environmental factors (temperature, wind). The data are stored on a memory card and then can be analyzed and interpreted accurately.

The sensor is attached between the insole and shoe (fig. 6.1, fig.6.2) and connects via a flexible cable to a microcontroller with a cord installed on the outside of the running shoe without interfering the running (fig. 6.3).

A sensor and a microcontroller module are fitted on each shoe. The starting point of the devices is achieved by simultaneously pressing the switches on microcontroller modules.

Synchronization is achieved by performing a vertical jumping on both feet. From this point forward the data are recorded on memory cards using taylormade applications. At the end, the switches are pressed and the devices are shutted. The data on memory cards are downloaded into a computer and then processed through specially developed software.

Fig. 6.1 Sensor placement on the insole

Fig.6.2
Sensor placement within the running shoe

Fig. 6.3.
Module placement on the shoelace

This device and the technical solutions are subjected to a patent analysis, registered at OSIM and available on Web of knowledge at the address:

http://apps.webofknowledge.com/full_record.do?colName=DIIDW&recordID=2013L53559&log_event=no&page=1&qid=1&log_event=yes&viewType=fullRecord&SID=Z2OylEj2jybfdMr8kvm&product=UA&doc=5&search_mode=GeneralSearch.

(B-ii) The evolution and development plans for career development

After obtaining the PhD title, the author was able to define his research directions towards which his activity has focused. Thus, the author's research has been targeted in the following areas:

A. Researches on improving physical education and sport educational process;
B. Researches in the field of sports management;
C. Studies and researches on sports biomechanics.

Today, the author's carrer is focused on both scientific research and academic activity. The following research directions are considered at the present moment as being important for the author's future development. On the other hand, it has to be highlighted that, although each direction outlined below can be considered independent, there is also an obvious overlapping between them.

CHAPTER 1
Directions related to scientific development

1.1. New approaches in physical education and sports

This is an important coordinate of the author's future scientific concern and a constant one, due to the fact that the activity is strongly related to this subject. It is important to face the present challenges in physical education and sports and to be able to rise up to them. Bachelor students, master students and teachers who want to get their first degree are well informed and guiding them to achieve their goals requires a constant search of new approaches in physical education and sports training. As their coordinator, it is important to be informed, to permanently improve and to be able to reveal the most important issues in physical education ans sports.

1.2. Developing applications for MGM test

The author is the manager of the „Research center for human performance" and together with a multidisciplinary team has developed several devices and applications for biomechanics of sports.

Developing the MGM test is a future research direction considering that new opportunities arise as consequence of the firendly interface already developed, which is now providing individual reports and interprets the data.

Extended researches will be conducted for the female and male handball and badmington teams. The application will generate instantly reports on each athlete and the trainer will have to schedule individual traning programs, in order to improve the energetic and control parameters.
Further applications of MGM test will be more complex, because the kinect sensor will be also a part of them. Thus, the kinect sensor will provide information on the stresses to which the joints are subjected during vertical jumping. The coaches will have to combine different strategies for

developing the poor motor abilities and to increase the strength of human joints, to prevent injuries.

1.3. Extended applications of Kinect sensor

The kinect sensor will be the main element in developing data acquisition system based on reconstruction of human skeleton.

Special applications and interfaces will be created in order to observe and check the progress or quality of technical executions in different sports fields over a period of time, thus keeping them under systematic review. For example, if a tennis player is monitored, the kinect sensor connected to a computer will provide information on distances, trajectorie, velocities, and reaction forces in joints. It is also important to decompose the images and to analyse frame by frame the technical executions.

The coach will be able to see the time variations of reaction forces in joint and the addapt the training program to the individual particularity.

1.4. Developing applications for LateraTEST – device for assessing laterality

As mention before, the author has built a mechatronic device for assessing the laterality, named LateraTEST. Further researches will provide applications and exprimental tests on that platform.

For assessing the reaction rate and establishing the dominance of cerebral hemispheres, the following steps will be required:

1. Calibration of mechatronic device. Initializing the variables;
2. Setting the groups that will be tested to determine the reaction rate and laterality (with respect to the categories to be tested, namely athletes, children and people with slight neoro-motric deficiencies);
3. Initial testing of groups participating in the experiment and generating reports for each individual;
4. Psycho motor interpretation of the results for each tested participant.

For improving the reaction rate and the dominance of cerebral hemispheres using specially designed training programs the following steps are mandatory:

1. Develop training programs to improve the reaction rate for athletes with right or left laterality in order to stimulate the two hemispheres of the cerebral cortex;
2. Implementation of programs to the participants in the experiment - athletes group.
3. Develop training programs to improve the reaction rate for children with right or left laterality in order to stimulate the two hemispheres of the cerebral cortex;
4. Implementation of programs to the participants in the experiment - children group;
5. Develop training programs to improve the reaction rate of people with neuro motor slight disabilities in order to stimulate the two hemispheres of the cerebral cortex;
6. Implement programs to the participants in the experiment - people with disabilities group.

For the final test, interpretation of results and generating progress reports, the steps are:

1. Testing participants and running the software. Data recording.
2. Interpretation of results for each individual participant in the experiment;
3. Generating progress reports with conclusions and proposals for future improvement.

The experimental mechatronic system is an innovative one, as there are not such devices to determine laterality and improve the reaction rate on the left / right side. The system can be successfully used by athletes, by physiotherapists to recover individuals that have temporarily lost the upper limb mobility, for children to stimulate both brain hemispheres, from an early age. The mechatronic system will open new research directions in evaluation of laterality and for studying neuronal processes that determine the response to stimuli.

Based on the study of literature and Batak system used to measure the reaction rate, measured as the number of buttons pressed in 30 seconds, emerged the idea of building a mechatronic device by which to test and improve the speed of response to visual stimuli.

The proposed system will allow the generation of random sequences of lightening smart buttons with white or colored light, and the software will allow data collection to determine the reaction rate for left / right side, the interpretation of data and will generate reports.

Regarding the experimental part, it will include tests conducted on three groups of subjects: athletes, children and persons with slight neuromotor dissabilities. For each individual random testing programs will be generated, thus, the author will be able to evaluate the left / right speed rate to white light stimuli.

The software allows the generation of evaluation programs in which the smart button will generate colored light (red, blue, white, green), also randomly. Subjects are asked to press the buttons with colored light (eg. only red buttons, or just green and blue buttons, etc).

The software allows the generation of reports for these cases, evaluating the left / right speed rate, analyzing also the responses to coloured visual stimuli. The data will be statistically analyzed for each testing protocol and initial status reports will be generated. The next step will consist of developing training programs using the same mechatronic system.

The training will be customized and adapted to each individual participant in the experiment. The next step will be the final testing, monitoring the progress of each participant of the three categories. The participants testing will be under laboratory conditions, temperature, brightness and noise level limits. Subjects will be aware of the experiment protocols and their consent will be required for participation in the experiment. In regard to children, they will participate in the experiment only with parental consent. The experiment is non-invasive and does not cause trauma to participants.

Another research idea is to build a portable device to determine and improve the reaction rate and the dominance of the cerebral hemispheres, with taylormade software which can run on android tablet or mobile phone.

With a portable device we will be able to make assessments of laterality and reaction rate under real conditions using special software installed on a tablet or a mobile phone with android, using a wireless data transmission.

Using the BIOPAC system together with LateraTEST we will be able to determine brain nerve stimuli, and muscle reactions controlled by brain nervous centers. It will improve the athletes' performance, will be able to relieve slight deficiencies of persons with neuro-motor skills and could form the laterality left / right for children.

1.5. Device for monitoring the athletic skills in real conditions

The device for monitoring the athletic skills in real conditions comprises pressure sensor which is attached between sole of shoe and insole and is connected by means of flexible connection cable to micro-controller module.

The device is dedicated for monitoring the athletic skills in real conditions, for data acquisition regarding the studying of walking and running in athletics and for studying the simple running step and also for analyzing the energetic and control parameters influencing the reaching of high performances. The device comprises a pressure sensor which is attached between the sole of a shoe and an insole thereof and is connected by means of a flexible connection cable to a micro-controller module mounted by means of a lace on the outer side of a running shoe. The data from the memory card are downloaded into a computer and subsequently processed by means of elaborated software.

Future researches will be focused also on that device. It will be a real challenge to collect data and to analyse it in order to get more accurate information on the running stages, on fatigue and on endurance.

CHAPTER 2
Directions related to academic development

Since 1998 the author has been working at „Dunarea de Jos” University of Galati. For the next stage of the candidate’s career he plans to study and graduate courses for accomplishment, that will help adjusting to the dynamics of academic life and its requirements, together with breakthroughs in research.

An important objective, which the candidate will have continuously in his mind, will be to update the existing didactic materials, and to include more applicative activities as well as the last findings in each topic followed in the lessons that he is teaching. As always, the candidate will carry out teaching considering new methods and techniques used to increase the attractiveness of teaching aimig to better use of pedagogical knowledge. The candidate will develop teaching materials, course materials, practical guidance for all subjects that he will teach in the future. Also, the candidate will re-edit and update existing teaching materials.

As for the students’ activity, the candidate will guide scientific circles, graduation and dissertation papers. He will also try to involve students in extracurricular activities (collegiate competitions, competitions between students and teachers, competitions among students and pupils etc).

As before, the candidate’s involvement in school life will be at the highest level, promoting the image of the faculty and the university, being an active member of committees and he will try to index the journal faculty in other databases.

As director of the research center, the candidate will be involved in joint research groups and together they will develop projects and the research results will be published in significant journals.

The author will remain engaged in organizing the annual conference of the faculty and will endeavor to increase the visibility of the conference by publishing the best papers in the volume of the journal Proceedia - Social and Behavioral Sciences, indexed Conference Proceedings Citation Index (Web of Knowledge - Thompson Reuters) as he already did for the last conference.

The candidate will continue his work at University Sports Club Galati, guiding the athletes and he will continue to organize the National Championship of ships model class C.

CHAPTER 3
Stategies considered for enhancing the scientific output

The objective to enhance the scientific output, in both quality and quantity, can be fulfiled only by promoting a coherent strategy, directed to develop multidisciplinary research teams, joining scientists from various institutions with complementary expertise that cover the outlined research fields. In this way, the candidate will be able to extend her aria of expertise by means of a continuosly knowledge transfer process.

On the other hand, an important place in the research teams that the candidate will try to develop is taken by the PhD students and the post-doc fellows.

Finally, it can be concluded that the candidate can and will try to continuously improve in the future both his scientific performance and his international visibility and the charge to supervise PhD students will represent for sure a real opportunity to enhance, both qualitatively and quantitatively, his personal professional achievements.

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