SECURITY DIMENSIONS
INTERNATIONAL & NATIONAL STUDIES
NO. 11; 2014 (106-114)

USE OF CRIMINALISTICS AND FORENSIC SCIENCES AT ENSURING THE POPULATION SECURITY

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ABSTRACT

In paper there are well-ordered given present directions of development forensic biomechanics. The author carried out the analysis of 100 expert opinions performed since 1994 in professional field "Criminalist, subject field forensic biomechanics" in cases that were concluded by court authority. According to analysis of needs of practice and expert investigations the author gives real prediction of further directions of research in forensic biomechanics. Forensic biomechanics invokes in investigation process, particularly violent criminal acts; by expert investigation it may come to conclusion on mechanisms of criminal act, action of extrinsic force and expression to consequences of this extrinsic force. Directions of development of forensic biomechanics are given by author in following applications - biomechanics of fall from high, judgment of extreme dynamic burden of organism, biomechanical analysis of fall from stand on a ground or fall from stairs, biomechanical analysis of walk and analysis of conflict combat. These directions represent 90% of all processed expert opinion.

ARTICLE INFO

Article history:
Received: 24.04.2014 Accepted: 08.07.2014

Key words:
criminalistics, forensic science, security, biomechanics

INTRODUCTION

Forensic sciences are very closely connected with criminalist as a scientific discipline and come in useful particularly as expert fields, e.g. judicial medicine, judicial psychiatry, judicial psychology, judicial sexology, forensic biomechanics, judicial engineering and forensic dentistry.

In last ten years forensic biomechanics has been very intensively used at investigations. From the historical view the forensic biomechanics is relatively very young field in the forensic science system. Biomechanics was firstly very marginally used at solution of problems in criminalist in 60s and in 70s years of last century[1] there has been developed research of biomechanical applications. In the second half of 90s the forensic biomechanics systematically started to develop also at criminalist department of the Police Academy of the Czech Republic in Praha.

As another forensic fields so analogically forensic biomechanics goes out of maternal field biomechanics and during the development it has been generating findings from expert practice and has been made own scientific and research base, directions of development and there are specified real

[1] During the development there was firstly used denotation „biomechanical content of criminalistic tracks", later there was generated term „Criminalistic biomechanics"

possibilities for use of forensic biomechanics in expert activity. Forensic biomechanics profiled insofar as self-reliant field that in last years there are in investigation process asked expert opinions from field "Criminalist – specialisation forensic biomechanics" in far often extent than in past.

PRESENT APPLICATIONS OF FORENSIC BIOMECHANICS IN CRIMINALISTIC

Generally, forensic disciplines took out from broader scientific disciplines because to certain standard questions there were very often required judicial expert opinions. Step by step in their frame there was started to develop own research activity that has been using not only knowledge base of motherly discipline but also generalised experiences for expert activity[2]. The origination of forensic biomechanics we can see in two sources. On the one hand there were findings peculiar to biomechanics as maternity discipline and simultaneously generalisation of findings from expert and criminalistic practice.

Forensic biomechanics is sciential field that applies biomechanics and biomechanical methods at investigation of criminalistic tracks with biomechanical content and on decode of information from criminalistic relevant event that originated as a consequence of human motion activity and that is related to investigated event. Forensic biomechanics investigates and explains this domain of criminalistics tracks that inherently contain biomechanical content, i.e. given applications give out information on muscular and skeletal form of offender or his / her motion behaviour. Forensic biomechanics has subject of investigation in common intersection of biomechanics and criminalistics. By creative way it applies investigation biomechanical methods, procedures and ways of solution of biomechanics to criminalistics problematic. Forensic biomechanics studies and investigates motion system and human motion behaviour that are related to criminal act and left behind criminalistics tracks that inherently contain biomechanical content. By denotation "forensic" biomechanics we meant "judicial" biomechanics then application of biomechanics in investigation and examination of criminalistic tracks[3].

Forensic biomechanics applies biomechanics and its cognitive methods to two important directions of investigation, namely:

- criminalistic tracks with biomechanical content,
- criminalistic relevant changes that originated as consequence of mechanical interaction of system "human-vicinity".

By theoretical analysis it is possible to divide several periods of forensic biomechanics development[4]. In this paper there will be presented own experiences with expert activity and with requirements of police commissioner entrusted by investigation.

Summary of present expert practice since beginning the use of expert opinions in the field "Criminalistic, specialisation forensic biomechanics" leads to knowledge generalisation and to outlining the present direction of forensic biomechanics development. For this paper there were selected 100 opinions of specialisation "Forensic biomechanics" processed in cases that were concluded by court authority. Total number of collected opinions is sufficient great number of cases from viewpoint of mathematical statistics and enables to show how forensic biomechanics is used. In the following table there are summarised

[2] MUSIL, J., KONRÁD, Z., SUCHÁNEK, J. *Kriminalistika.* 2. přeprac. A dopl. vyd., Praha: C. H. Beck, 2004, s. 11.

[3] STRAUS, J. *Aplikace forenzní biomechaniky*. Praha: Police history, 2001, s. 17

[4] STRAUS, J., VAVERA, F. *Dějiny československé kriminalistiky slovem i obrazem II.* Praha: Police history, 2001, s. 131

processed expert opinions from the 1994-2007 time period ranked according to problem[5].

PROBLEMS	NUMBER OF CASES
Biomechanics of fall from high – judgement of cause by strange person, impact of extrinsic force	**43**
Extreme dynamic burden of organism – usually strokes to head, judgement of question of organism tolerance, surviving the origination of fracture of cranial bones	**24**
Fall from stand on a ground, fall from stairs – judgement of fall course, possibility of strange cause, causes of fall	**15**
Biomechanical analysis of walk - identification of person according to walk stereotype, determination of geometric characteristics of persons	**4**
Analysis of conflict combat – determination of reaction times, possibilities of strength impact, reality of protective reactions	**4**
Traffic incidents – mechanical impact on traffic incident participants being inside vehicle and mechanical impact on run down person	**3**
Knifing – strength impact at knifing, possibility of participation of second person, determination of force to skin transpiercing	**2**
Biomechanical content of run tracks of local motion – prediction of physical tallness and of way of local motion according to leaved tracks of local motion	**1**
The other – sporadic cases, e.g. person injure by casted grenade, injure of ligaments in knee at combat, shaking the child head, halter, fatal injure at jump to distance	**4**
Total	**100**

[5] Into survey there are included expert opinions processed by V. Karas, obtained by author from him as a gift during his life and from his inheritance and the own expert opinions.

Given table shows percentage distribution of investigated cases of two experts (Professor Karas and Professor Straus, the author).

It is remarkable than in practice the investigation of biomechanical content of run tracks of local motion has not been spread in higher extent. Scientific research is very well processed in this direction, there is to disposal a lot of mathematical dependences for prediction of physical tallness from tracks in different disperse surround, but they have not been realised in practice. It is evident that there are not found out tracks of local motion, nevertheless the research of biomechanical content of run tracks of local motion instigated the identification of persons according to dynamic walk stereotype. In last 5 years the research of human local motion transforms to identification of persons according to dynamic walk stereotype.

It follows obtained experiences from the use of forensic biomechanics.

Biomechanics of fall from stand is very frequent application and from viewpoint of forensic biomechanics relatively well investigated application[6]. The current research directs in two directions. Firstly, it is experimental research that studies human body motion divided into phases at fall or jump from stand. Experimental persons jump from tower into water, their motion is recorded on film and consecutively analyses with time sampling 40 ms. There is studied the motion of centre of gravity of body and rotation of individual axes of body[7]. The second research direction is aimed to analysis of criminal cases. We cumulate well documented real cases at which fall of victim was happen, e.g. documented suicides, murders, unfortunate events. By assembling and comparison of biomechanical values at experiments and real cases we have sufficient material for real programming and analysis of fall of human body from stand. For reconstruction of biomechanics of fall of human body from stand we created the PC program "Virtual Crash3", that allows to simulate the human body fall in 3D space according to given input parameters. This lucidly allows very to reconstruct individual variants of fall differentiating three cases, e.g. variant of active jump, unfortunate event (sliding) or variant of active outer force (pushing by other person). Model approach for solution, e.g. biomechanics of falls, is always limited because object is biological system that in some situations need not behave as multilateral mechanisms of relatively stiff elements. Therefore, in this direction we perform broad comparison of experimental data and analysis of well documented criminal acts.

According to own experiences the biomechanical analysis of fall from stand enables to solve questions of following type:

1. Was fall form stand spontaneous, without attached outer forces, i.e. does person fall without strange cause, without pushing out, possible without own rebound?
2. Was vice versa fall caused and impact affected by outer forces, i.e. does person rebound or was person pushed out?
3. Is it possible to calculate the size of affected outer force in moment of loss of contact?
4. Does distance of body landing from vertical line correspond to probable height of fall?

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[6] STRAUS, J. a kol. *Biomechanika pádu z výšky.* Praha: PA ČR, 2004.

[7] Experimentally there were tested falls of body to rescue fire fighter canopy, falls of human body model or scale body model. Falls of persons to swimming pool showed as optimum.

5. In case that person rebounded is it possible roughly to calculate size of vector of velocity of rebound?
6. Is it possible according to fall and landing to judge on suicide jump or unfortunate event or intentional pushing out by second person?

Extreme dynamic burden of organism represents a situation, in which attacker assails victim with a stroke by fist, stone, hammer, baseball bat or by another solid thing. The most often the attack is directed to head of victim because brain is livingly important organ. In case of these biomechanical analyses it is taken into account the judgement of organism resistance, its tolerance to outer loading. Forensic biomechanics enables precise quantification of organism tolerance to outer loading, it is possible to calculate what stroke leads to bruise of brain tissue, bound fracture and by that detection of reality if assailed person died immediately or a certain time person lived on and theoretically it was possible to rescue him / her[8]. Principally it is important to determine and to quantify the boundary important for surviving at mechanical extreme loading the head of victim. Also for variant of calculation of dynamic loading the head of human body from stand we compiled the PC program "IMPACT-HEAD" that allows simulation and calculation of critical values of tolerance of organism resistance, shock component of force for origination of fracture of cranial bonds, origination of unconsciousness or destruction of brain tissue. The PC simulation in the 3D space goes according to input parameters.
In this direction of application it is possible to solve the following questions:

1. Biomechanical description of motoric behaviour at which injury of impaired person originated.
2. How great force and energy originates at stroke and whether person is capable to produce it, whether it corresponds to description of motoric behaviour?
3. Whether values of outer loading are capable to cause founded injury in domain of head.
4. To express to boundary of organism tolerance to outer loading.
5. To judge ways of physical attack of injured person.
6. From viewpoint of biomechanics to express to probability of course of physical conflict (attack) of accused person and injured person.
7. To express to number of strokes to head, eventually to body.

Research in this direction enables very precisely to describe behaviour of human body and its parts to outer loading and quite precisely to quantify the organism tolerance[9].
Fall from stand on a ground, fall from stairs. Falls from stand on a ground are relatively frequent biomechanical problem. From the viewpoint of biomechanics we distinguish three sorts of incidents at walk, that lead to falls. It is sliding, tripping and stumbling with followed fall. In biomechanical literature there are these three kinds of incidents described and clearly distinguished not only according to way of origin but also according to determining step – direction of fall, distance of landing from origin of fall,

[8] STRAUS, J. *Biomechanika tupého poranění organismu*. Praha: PA ČR, 2000; STRAUS, J., Tolerance lebky a mozku na vnější mechanické působení. *Soudní inženýrství*, 18, 2007, č. 1, s. 42-49

[9] STRAUS, J. Balance of Mechanical Energy at External Head Impact. Research Papers: *Criminalistic and Forensic Examination: Science, Studies, Practice*. Vilnius 2007, s. 169-173; STRAUS, J., PORADA, V. Forensic Biomechanical Application in Criminalistic. *Forensic Science International.* Volume 169, Supplement 1, 2007, s. 40 STRAUS, J. Balance of Mechanical Energy at External Head Impact. Research Papers: *Criminalistic and Forensic Examination: Science, Studies, Practice*. Vilnius 2007, s. 169-173

place of body landing, final position or orientation of body and nature and extent of injury. This detail information must be in-depth founded for objective judgement of course and cause of fall. Given sort of falls is frequent at two age different groups. Often it is detected at young teenagers as a consequence of fall of skating on-line skates or skateboard and at old people who trip as a consequence of bad motoric and co-ordination of motions at walk. In criminalistic there are also important cases at which attacker pushes a victim, it falls and injures and it is important to judge it fall of attacked person was in direct consequence of stroke or if it originated as a secondary phenomena.

Biomechanics of fall from stand on a ground and falls from stairs enables to solve according own experience the following questions:

1. From viewpoint of biomechanics to judge mechanisms of fall.
2. If fall was spontaneous without attached outer forces (i.e. strange cause – pushing).
3. Was landing caused by action of outer force?
4. Whether described injuries could be caused by spontaneous fall without participation of second person.
5. Whether it takes into account action of outer force of second person.
6. In case of participation of other person to express to size and direction of action of force.
7. Whether mechanisms of injury corresponds to given explanation.

Biomechanical analysis of walk is very perspective application. Problems of identification of persons according to walk is not new matter (the first application has been appeared since beginning 90s[10]), it is very interesting domain, particularly for its application in domain of security. At present the research connected with identification of person according to dynamic stereotype of walk very intensively studied abroad[11] and also in the Czech Republic[12]. In comparison with other biometric identification methods the identification according to walk ha many advantages. One of them it is reality that shots taken by video camera used for identification may be recorded at relatively low recognition. From this it follows that observation may be performed from relatively great distance without person might know that he / she is monitored, i.e. the identification according to walk is non invasive characteristics. It is also more heavy suppress the walk in comparison e.g. face because humans need to move. These characteristics make up from identification according to walk relatively attractive biometric characteristics.

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[10] Grounds of identification of persons according to walk established JOHANSSON (JOHANSSON, G. Visual motion perception. *Scientific American*, (232):76–88, 1975.) in his experiments with display of light points (in literature denoted as the PLD). His experiments proved capability of persons to distinguish another person according to way of walk only on the basis of observation of 2D curves created by fixing bulbs on persons.

[11] NIXON, M. S., et. al. Automatic Gait Recognition, *In:* A. K. Jain, et al. Eds., *Biometrics: Personal Identification in Networked Society*, pp 231-250, Kluwer, 1999; NIXON, M.S.. CARTER, J.N.NASH, J.M HUANG, P.S. CUNADO, D. Stevenage, S.V. Automatic gait recognition. In *Motion Analysis and Tracking (Ref. No. 1999/103), IEE Colloquium on*, pages 3/1–3/6, 1999; NIXON, M.S., TAN, T.N., CHELLAPPA, R. *Human Identification Based on Gait.* Springer-Science+Business Media Inc., 2006; ABDELKADER, C. B., CUTLER, R., NANDA, H., DAVIS, L. EigenGait: Motion-Based Recognition Using Image Self-Similarity, *LNCS* 2091, 2001, pp 289-294; LYNNERUP, N, VEDEL, J. Person Identification by Gait Analysis and Photogrammetry. *J. Forensic Sci.*, 50, 1, s. 112-118.

[12] STRAUS, J., JONÁK, J. Lokomoce člověka z hlediska forenzní biomechaniky. *Pohybové ústrojí*, 11, 2004, č. 1-2, s. 130-131; STRAUS, J., JONÁK, J. Je možné identifikovat osobu podle pohybového projevu lokomoce ? *Policajná teória a práx*. 3, 2005, s. 109-120

Disadvantage of identification of person according to walk is fat that even though each person has theoretically unique walk under ideal conditions, the change of conditions (e.g. clothing, light conditions, angle of camera or even velocity of walk) may cause more deviations at one person then between two different persons, moreover humans can intently change the way of walk. These circumstances lead to discussions how precise identification according to walk may be. Identification features performed at the Police Academy of the Czech Republic confirm the fact that dynamic stereotype of each person is unique and it is possible to identify person according to walk. Research findings allow apart from individual identification of person to calculate some supplementary characteristics as it is e.g. person tallness. It was published many studies using different parameters with different results. Some of these methods are relatively time consuming and require storing and analysis of many data.

With regard to own experiences the bodies active in criminal action require the answer to the following questions:

1. To calculate tallness of person, pertinently bulky characteristics of person.
2. To carry out individual identification of person.

Further there will be given main aiming of other applications of forensic biomechanics and nearer subject of investigation according to own experiences and findings consulted with police commissioners.

Analysis of conflict combat is used in cases in which there is physical attack of person, affected person and attacker present different version of course of physical conflict and by expert investigation there is evaluated question dealing with possible courses of movements. It is most often the judgement of reaction times of motoric behaviour and velocity of stroke performance, head turning away, speed of defensive reactions etc. In these cases it is necessary to take into account to possible training the participants in fight, whether push was from guard position, with preparation, without preparation etc.

Traffic incidents use the biomechanical investigation at assessment of mechanical action on traffic incident participants inside vehicle and mechanical action on sour persons. By expert investigation it is possible to express to position of persons inside vehicle during the traffic incident, determination of critical bump velocity and origination of injury of persons and to their possible fasten by safety belts. E.g. at bump of vehicles it originates injury of persons and by biomechanical investigation it is possible to express whether driver or co-driver were fasten by safety belts.

Knifing is also relatively frequent. Biomechanical analysis investigates size of force that must be produced at stab, next possibility of participation of another person and expression to active action at stab.

Biomechanical content of run tracks of local motion is really very low used application, even though theoretical findings are very prosily processed. In own practice there was solved only one case of prediction of tallness of offender and of way of local motion according to leaved tracks in ploughed land.

The other are single cases and sometimes too curious, e.g. injury of person by thrown grenade (pupil throw grenade at class of physical education and injured teacher), injure of ligaments in knee at combat, contusion of child brain at its shaking (father shake with child with intent to knock out the bead from respiratory path, consequence – intracranial bleeding of child), hanging (judgement of motion behaviour of felo-de-se at hanging on tree branch), fatal injure at jump to distance (pupil at athletic event unhappily bounded at concrete margin of pit and injured liver, biomechanical judgement solved variant if pit was from soften material) etc.

CONCLUSION

Performed analysis of expert opinions from field "Criminalistic, specialisation forensic biomechanics" enables real judgement of present directions of development of forensic biomechanics in criminalistic according to experiences of expert practice. In paper it is analysed set of cases compiled by two experts, for which there is expert opinion from field "Criminalistic, specialisation forensic biomechanics". It is evident that problems of forensic assessment of falls and local motion are substantially multifarious with possible interference of different psychomotoric influences that can proper fall mechanics modify.

According to analysis of expert opinions there is possible to determine per cent distribution of cases solved by two experts (professor Karas and author) on the basis of 100 real closed cases. Practical application of forensic biomechanics in criminalistic are according to own experiences in following directions – fall biomechanics (43%), judgement of extreme dynamic loading the organism (24%), biomechanical analysis of fall from stand on ground or fall from stairs (15%), biomechanical analysis of walk (4%) and analysis of conflict (4%). These directions represent 90% of all processed expert opinions. According to practical experiences it is possible to assume that given used directions will also in future develop and determine research trends.

At the end it is necessary to remark that opinions given in paper presenting the outline of directions of development of forensic biomechanics in criminalistic in the Czech Republic, were drawn from own experience and expert practice and also from Professor Karas expert practice. Discussion to given trends and possible specification and supplement will be very useful for further development. Degree of cognition of new ideas and theories only originates in conflicts of opinions and in correct scientific discussion.

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