USING THE RASCH MODEL TO IMPROVE THE QUALITATIVE ANALYSIS OF THE OVERARM THROW

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Abstract:

The purpose of this paper is to show how the Rasch model of item response theory (IRT) can be used to improve the qualitative analysis of human movement, e.g. the overarm throw. The overarm throw is a fundamental movement pattern of many sports skills. The ability to analyze it is a critical teaching and coaching skill. The Rasch model should help to recognize the difficult critical features of the movement. One hundred and twenty nine children took part in this study (88 boys, 41 girls, ages ranging from 12 to 14 years). The data were taken from videotapes of the actual performance of subjects. It has been found that applying the Rasch model can be both simple and practical since in its terms the most difficult critical features of the overarm throw were clearly identified.

Key words: *Rasch model, qualitative analysis, overarm throw, motor skills*

RASCH-MODELL-VERWENDUNG ZWECKS DER VERBESSERUNG VON QUALITATIVER ANALYSE DES ÜBERKOPFWURFES

Zusammenfassung:

Das Ziel dieser Arbeit ist zu zeigen, wie das Rasch-Modell der Item-Response-Theorie (IRT) verwendet werden kann, um die qualitative Analyse menschlicher Bewegung, z.B. des Überkopfwurfes zu verbessern. Der Überkopfwurf ist das fundamentale Bewegungsmuster in vielen Sportarten. Die Fähigkeit, ihn zu analysieren, ist die kritische Eigenschaft der Lehrer und Trainer. Das Rasch-Modell soll helfen, die komplizierten kritischen Bewegungseigenschaften zu erkennen. 129 Kinder nahmen an dieser Studie teil: 88 Jungen und 41 Mädchen, im Alter von 12 bis 14 Jahren. Die Daten wurden von Videoaufnahmen eigentlicher Ausführungen abgenommen. Es wurde beschlossen, dass die Verwendung des Rasch Modells einfach sowie praktisch sein kann, weil auch die schwersten kritischen Eigenschaften des Überkopfwurfes eindeutlich identifiziert wurden.

Schlüsselwörter: *Rasch-Modell, qualitative Analyse, Überkopfwurf, motorische Fertigkeiten*

Introduction

The overarm throw is a fundamental movement pattern for many sports skills. The correct performance of this movement has a strong influence on the final performance of athletes. A large number of researchers (e.g. Blahuš 1971; 1996) have analyzed various release conditions in motor skills, such as the overarm throw, especially in the javelin throw (e.g., Milanović, Mejovšek & Hraski 1996; Ariel, et al., 1980; Terauds, 1978). Mostly they dealt with the biomechanical analysis of performance of individual top athletes. But we are looking for some practical recommendations for developing teaching and coaching skills in throwing. The problem is to quantify the correct realization of a motor skill. There are many variables and we have to reduce the number of them by using a theoretical model. An integrated model of qualitative analysis seems to be most appropriate. It can give students helpful clues that will lead to improved overarm

throwing performance. The purpose of this study was to evaluate the difficulty of the critical features of the overarm throwing skill by the Rasch model and to give more distinguishing capacity to the integrated model of the qualitative analysis of this skill (Čepička, 1999).

Integrated model of qualitative analysis

Qualitative analysis can be defined as the systematic observation and introspective judgment of the quality of human movement for the purpose of providing the most appropriate correction procedures to improve performance (Knudson & Morrison, 1997). It is based on the information from many sub-disciplines of physical education (biomechanics, exercise physiology, motor development, motor learning, pedagogy, sport psychology) which influence four goals of analysis: preparation, observation, evaluation/diagnosis and correction (Knudson & Morrison, 1996). During the preparation the researcher has to collect the relevant information about motor skill and especially about their critical features. The analyst must create a theoretical model of movement and he or she has to have an idea of its correct realization. It is very helpful to use a biomechanical model of movement at this point of the analysis.

The next part of the analysis has to be based on the systematic observation of performance of the subject. Usually, the analyst observes several trials and takes a videotape of them. This is a very important part of the analysis because the researcher needs to evaluate human movement which is otherwise impossible to measure, and the researcher has to distinguish between the correct realization of motion, i.e. the critical features of motion, and the incorrect realization of motion. We suppose that using the Rasch model should be very helpful at this point of qualitative analysis.

Rasch model

Solving measurement problems with the Rasch model has recently become popular. This model, proposed for personal measurement, is relatively simple and has the fewest components, namely just one so-called ability parameter for each person and a difficulty parameter for each item. What is an item in human movement measurement? For example, it can be an alternatively scored motor test or a motor skill which the analyst evaluates as right or wrong. The Rasch model is one of the latent-trait models (an individual's "ability" has a latent character) which has been proposed for binary data analysis. The alternatively scored motor test gives binary data, right or wrong, yes or no, 1 or 0. The Rasch model parameters represent the positions of persons and items on the latent variable they share. They are used in the model to determine the probability of a person to succeed in item performance. So, let us say the Rasch model works with the probability of the right response to an item. This probability can be described by a nonlinear functional relationship which is expressed by the equation:

$$\mathbf{P_i(\theta_j)} = \frac{e^{(\theta_j - \beta_i)}}{1 + e^{(\theta_j - \beta_i)}},$$

where $P_i(\theta_j)$ is the conditional probability of the correct response of a person *j* to the item *i* given the latent level of his/her ability θ, β_i is the difficulty parameter of item *i* and θ_j is the ability parameter of a person *j*.

Although the ability or difficulty scale extends from $-\infty$ to $+\infty$, the range of commonly obtained values is from -3 to +3. When [a] person has more of the latent ability than [an] item requires, then his or her probability of success in the item is greater than 0.5. The more difficult the item for a subject, the lower his or her probability of success. The relationship between a person's ability, the item's difficulty and the probability of a correct response are presented by an item characteristic curve (Figure 1).

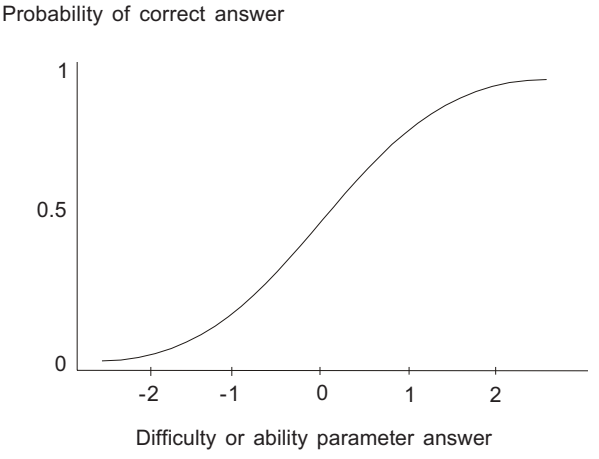

Figure 1. The Rasch model characteristic curve for a typical item - a feature of movement

According to Spray (1987) there are two basic assumptions of the Rasch model:

(1) *The unidimensionality* assumption. It is assumed that ability (latent trait) represents just one dimension.

(2) *The local independence assumption* which assumes that the responses to two items are unrelated for a given ability level θ. Thus, the Rasch model gives us an opportunity to estimate the subject's ability and the item difficulty independently of each other and independently of the sample of subjects as well. The levels of ability and item difficulty are independent of the sample distribution. This second assumption is very important for human measurement because in many cases motor skills or abilities do not have a normal distribution across the sample.

The precision of the estimation of parameters is quantified by a standard error of estimation. Generally, the smaller the standard error of estimation, the more precise the estimation of a person or ability parameter. How well the data fits into the Rasch model depends on comparing calculations for each item and person. Usually the χ^2 statistic is used which is based on the responses of all persons to the item. We can say that χ^2 will increase if a person with high ability and an easy item corresponds with a wrong response or when a right response is associated with low personal ability and high item difficulty.

Methods

Subjects

The sixth, seventh and eight graders attending an elementary school took part in this study (N = 129: 88 boys, 41 girls, from 12 to 14 years old). Some of them came from special physical education classes with a handball training program. Thus, there were many youngsters with different levels of throwing skills. According to the assumption of independence there was no influence of the different levels of throwing skill across the sample.

Measures

The integrated model of qualitative analysis of the overarm throwing by Knudson and Morrison (1996) was used. The critical features of the overarm throwing are described in the following paragraphs.

1. *Angle of release.* The optimal angle of projection for a ball thrown over a horizontal distance in most sport situations is between 35 and 42 degrees above the horizontal. The analyst has to evaluate the angle of release and trajectory of the ball to determine how the performer released the ball.
2. *Leg drive and opposition.* This critical feature combines the thrower's stance and step into the throw. Opposition is created by turning the non-throwing side of the body to the target. Leg drive occurs when the thrower pushes off the back leg and steps toward the target with the opposite foot.
3. *Setting up the body and the hip and trunk rotations.* This feature is connected with leg drive and especially with opposition. Strong leg drive transfers energy into hip and trunk rotation from the opposition towards the target. Leg drive, opposition and body rotation were involved in one critical feature of Knudson and Morrison's model. But on the base of our pilot study we have divided them into two separate critical features. The reason was that some youngsters had a strong leg drive but no hip or trunk rotation.
4. *Strong throwing position, trunk lean, arm position at release and inward rotation of the arm.* This feature involves keeping the upper arm at a right angle to the longitudinal axis of the spine. Inward rotation of the arm is the combination of humeral inward rotation, radio-ulnar pronation and wrist flexion that provides the final push to the ball.
5. *Sequential coordination.* It implies the precise coordination or timing of the segment actions that can transfer energy to distal segments. The sequential action of the leg drive, hip rotation, spinal rotation, arm, forearm and hand action are required to generate a high-speed throw.

We have used these critical features of the overarm throw to formulate five items. The items are described in Table 1 and they are identical with the critical features formulated in the model.

Table 1. Description of items

Item	Critical features of movement
Item 1	The angle of release and trajectory of the ball, rigidity of body, limited range of motion
Item 2	Leg drive and opposition
Item 3	Setting up the body and the hip and trunk rotations
Item 4	Strong throwing position and trunk lean, arm position at release
Item 5	Sequential coordination

The task given to the subject was to throw the ball over a horizontal distance. The throwing performances of the subjects were taken from a videotape and they were consistent throughout the observation. The throwing performance of each person was taken as a whole but the items were scored separately. If the subject performed the

critical feature correctly (according to the previous paragraphs), the item was scored 1. If he or she was unsuccessful, the item was scored 0. Thus we obtained 5 numbers from each person.

The data matrix was analyzed by the Rasch model and Germano Rossi's software Rasch 1.0 was used (Rossi, 1991).

Results

The values of the item difficulty parameter ranged from –0.410 to 0.647 and the mean was 0.0. They are presented in Table 2. As we can see the Rasch model fit to data is very good. χ^2 values were generally small and the probability values were high. It means that the assessed motor skill represents one dimension of the latent trait (overarm throwing skill) and only that. The values of standard error of the estimate (SEE) were small as well (they ranged from 0.213 to 0.225). The SEEs provided precise information about the estimation of parameters. So we can say that using the Rasch model was satisfactory in this data analysis.

segments in action was very good in the sample of subjects.

The most difficult part of overarm throwing is the critical feature which is described by item number four (difficulty parameter = 0.647). It is the inward rotation of the arm. This element of skill contributes to ball speed from 30 to 50 percent (Miller, 1980). Another very important thing is that the inward rotation of the arm is a protective mechanism against shoulder and elbow injury. The value of the difficulty parameter means that the correct movement of the arm is difficult to do.

The ability parameters in our sample ranged from –1.44 to 1.44 and the mean was 0.327. If we compare the ability mean and the mean of the item difficulty we can see that the level of skill in our sample was higher than the difficulty mean. We suppose that pupils from special physical education classes with a handball training program had an influence on this. But they had no influence on the parameter estimation.

Table 2. Estimation of item difficulty

Number of correct realizations	Difficulty parameter	SEE	χ^2	Degrees of freedom	Probability
72	-0.238	0.220	27.152	92	1.000
76	-0.410	0.225	28.283	92	1.000
57	0.367	0.213	27.928	92	1.000
50	0.647	0.216	28.663	92	1.000
75	-0.366	0.223	26.066	92	1.000

In Table 2 the values in column number three are most interesting. They are the parameters for item difficulty. Item 2 has the lowest level of difficulty compared with the other two items. It represents the critical features leg drive, step forward and opposition. This part of the throwing skill was observed in the majority of youngsters (76 cases) and it seems to be a natural part of the skill which is common to most people (especially the step forward). It was surprising that also the difficulty of item number five (sequential coordination) was very close to the difficulty of item number two. We supposed greater difficulty of this critical feature but the timing of the

For a better presentation of the item difficulty see Figure 2. The item characteristic curves are shown there. The levels of the item difficulty parameters are equal to 50 percent probability.

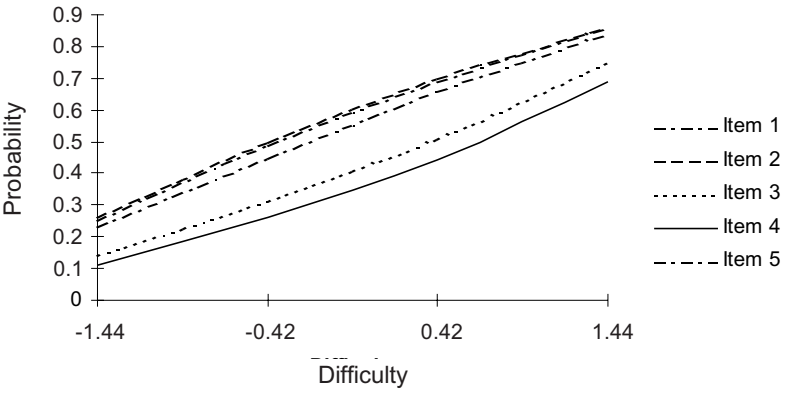

Figure 2. Item characteristic curves

Conclusion

Firstly, the results of Rasch analysis show that using the Rasch model to estimate the difficulty of motor skill is possible. It provided a more appropriate interpretation of human movement and the subject's motor skill than classical item analysis. Thus, we can estimate the difficulty of movement and the level of motor skill, or ability, of the person being tested independently of one another. The interpretation of the parameters, however, should be made with caution.

Secondly, the most difficult part of the overarm throwing skill is the inward rotation of the arm. This critical feature significantly contributes to the ball's speed. But it has another important feature, it helps to prevent arm injury. Thus, this movement is not just difficult but guards against injury to the athlete as well. What should coaches or teachers do? They have to observe the throwing position of the upper arm and focus on the arm rotation. They have to use their knowledge of biomechanics and motor learning to prescribe modified practice. Coaches could try to provide feedback to improve the inward rotation of the arm.

Thirdly, the leg drive, step forward, opposition and sequential coordination are relatively easy. However, it does not mean that they are less important. While developing the skill we do not need to focus on them so much because mainly they have the characteristics of skills which are common to all people.

Finally, any model of movement analysis helps to understand the motion. Any numbers or quantified characteristics only support the analysts' knowledge of movement and help to make the decisions about movement performance. There is no perfect approach for evaluating motor skills. However, an integrated model of qualitative analysis together with the Rasch analysis can increase the effectiveness of teaching motor skills.

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UPORABA RASCH MODELA ZA POBOLJŠANJE KVALITATIVNE ANALIZE BACANJA IZNAD RAMENA

Sažetak

Uvod

Cilj je ovog rada pokazati kako se uporabom Rasch modela teorije odgovora na zadatak (Item Response Theory - IRT) može unaprijediti kvalitativna analiza ljudskog pokreta, točnije analiza bacanja iznad ramena. To je pretpostavka za definiranje nekih praktičnih preporuka za unapređenje metodike poučavanja i treniranja motoričke vještine bacanja. Integrirani model kvalitativne analize čini se najprikladnijim za tu svrhu. Cilj ovog istraživanja bio je Rasch modelom procijeniti težinu izvedbe pojedinih kritičnih dijelova motoričke vještine "bacanje iznad ramena" te naglasiti prikladnost integriranog modela kvalitativne analize te vještine.

Kvalitativna analiza temelji se na informacijama iz različitih subdisciplina tjelesnog vježbanja koje utječu na četiri zadatka analize: pripravu, opservaciju, evaluaciju/dijagnozu i korekciju. Tijekom priprave za analizu analitičar mora stvoriti teoretski model pokreta i imati jasnu predodžbu o njegovoj ispravnoj izvedbi. U tom analitičkom koraku korisno je uporabiti biomehanički model pokreta. Sljedeća razina analize treba proizići iz sustavnog promatranja (opservacije) izvedbe strukture pokreta. Obično analitičar promatra nekoliko ispitanikovih pokušaja te ih snima video kamerom. Pretpostavljamo da bi Rasch model mogao biti vrlo koristan upravo na ovoj razini kvalitativne analize. Rasch model jedan je od modela latentnih osobina (individualna 'sposobnost' svakog pojedinca uvijek je latentnog karaktera) koji se koristi za analizu binarnih podataka. Alternativno procijenjeni rezultati izvedbe motoričkog testa poprimaju vrijednosti binarnih varijabli: točno-pogrešno, da-ne, 1 ili 0. Parametri Rasch modela (indikator težine zadatka i parametar individualne sposobnosti pojedinca) predstavljaju poziciju osoba i zadataka na latentnoj varijabli. Ti se parametri u okviru modela koriste za određivanje kolika je vjerojatnost da će odgovor ispitanika na pojedini zadatak biti uspješan.

Metode

Učenici šestog, sedmog i osmog razreda osnovne škole sudjelovali su u ovom istraživanju (N=129; 88 dječaka i 41 djevojčica u dobi od 12 do 14 godina). Za kvalitativnu analizu bacanja iznad ramena korišten je integrirani model Knudsona i Morrisona. Odredili smo kritične faze izvedbe bacanja iznad ramena kako bismo formulirali 5 zadataka.

Osnovni zadatak bio je da svaki ispitanik baci loptu ravno naprijed što dalje. Izvedba bacanja svakog ispitanika uzeta je kao cjelina, ali su pojedini zadaci bodovani odvojeno.

Rezultati i diskusija

Pokazalo se da Rasch model dobro odgovara ovom skupu podataka. To znači da je procjenjivana motorička vještina jednodimenzionalna latentna sposobnost (vještina bacanja iznad ramena) i ništa izvan toga. Analiza pokazuje da je uporabom Rasch modela moguće procijeniti težinu cjelovite motoričke vještine. Tako smo u studiji uspjeli odvojeno procijeniti zahtjevnost pokreta i razinu motoričke vještine ili sposobnosti pojedinog ispitanika. Parametre, međutim, treba interpretirati vrlo oprezno.

Najteži dio izvedbe motoričke kretne strukture (vještine) bacanje iznad ramena predstavlja rotacija ruke prema unutra. Ta kritična faza bacanja značajno doprinosi brzini leta lopte, no, istodobno, njena pravilna izvedba pridonosi sigurnosti izvedbe, posljedično sprečavanju ozljeda. Tako ovaj pokret ne samo da je težak za izvedbu, već je iznimno važan za zdravlje sportaša. Treneri bi se trebali potruditi da svojim sportašima osiguraju učinkovite povratne informacije o izvedbi toga segmenta pokreta kako bi poboljšali rotaciju ruke prema unutra. Pokret nogom, iskorak, opozicija (dijagonalna rotacija tijela - strana tijela suprotna ruci koja izbacuje loptu okrenuta je prema naprijed) i sekvencijalna koordinacija relativno su lagani za izvedbu. To ne znači da nisu važni. Ali, prilikom izvedbe vještine bacanja iznad ramena nije potrebno usmjeriti osobitu pozornost na poučavanje tih segmenata pokreta budući da su to većinom prirodne kretne strukture, zajedničke svim ljudima.

Zaključak

Integrirani model kvalitativne analize u kombinaciji s Rasch modelom može pridonijeti povećanju učinkovitosti poučavanja motoričkih vještina.