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# Motor screening for kindergarten children - A systematic review

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## Abstract

**Objective:** Motor deficits must be detected as early as possible to avoid negative consequences for the affected child. Within the framework of a sequential diagnostic strategy, screening should be used first in order to keep the testing effort for all children as low as possible. Thus, only children with conspicuous results need to be further examined. The present study investigates whether such procedures exist for kindergarten children and meet the required criteria. Design: Systematic literature research in different online databases and print media.

**Data sources:** Dialnet, ERIC, PSYNDEX, PubMed and SpoLit.

**Eligibility criteria:** Papers in English, French, German or Spanish, Motor tests, children from three to six years.

**Results:** There were 1013 publications found. After the eligibility screening process, the research shows that 21 alleged screenings exist. However, only five procedures meet the required criteria for screenings. Conclusions: MobiScreen 4-6, MOT 4-8 Screen and TGMD-3 are particularly recommended.

**Keywords:** Motor development, diagnostics, screening, kindergarten, developmental disorder

## Introduction

Only a few reviews indicate that different procedures exist that can screen the motor development status of kindergarten children. Their quality and underlying constructs of motor development are pointed out. The tests studied are mostly based on motor skills, abilities or competencies. Other relevant constructs, such as mobility according to the International Classification of Functioning, Health and Disability for Children and Youths ICF-CY of the World Health Organization WHO [1] are not addressed. Screenings are also not discussed. The procedures examined are usually time-consuming, and often expensive material is needed. Since children between the ages of about three and six still have a short attention span (about 15 minutes at the age of three to about one hour at the age of six) [2], the testing procedure should be kept as short as possible [3]. Children with motor development disorders or limitations are more clumsy than children of the same age in terms of gross or fine motor skills or coordination and need more time in assessments. In addition, many of the affected children suffer from ADHD or language development disorders. As a result, they often have problems coping with everyday life, such as doing handicrafts, or sitting still because their urge to move cannot be acted out. As a result, those affected become unhappy and frustrated, their self-esteem sinks because nothing is achieved despite their efforts. They often resist in order to avoid certain demands. This leads to further long-term negative consequences such as behavioural problems as a result of performance deficits [4]. In order to reduce or even prevent such long-term negative consequences, children with motor impairments or at risk must be identified at an early stage [5]. The identification of these children takes place within the framework of diagnostic assessments. A screening is intended to determine whether serious (motor) deficits are present [6]. It has a kind of filter function in the diagnostic process and serves as a quick orientation about a (developmental) abnormality [7,8]. It does not allow a specific diagnosis, it only classifies into “normal” and “not normal” [9]. Following a sequential diagnostic strategy, a screening should be used first. This reduces the number of children who need to undergo a detailed testing procedure [10]. This is because only children with positive/ “not normal” findings need to be referred for further detailed diagnostic testing [11]. Based on the information gathered from the tests, a diagnosis can be made and the child can then be referred for appropriate support. The follow-

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ing figure 1 [12] illustrates this process.

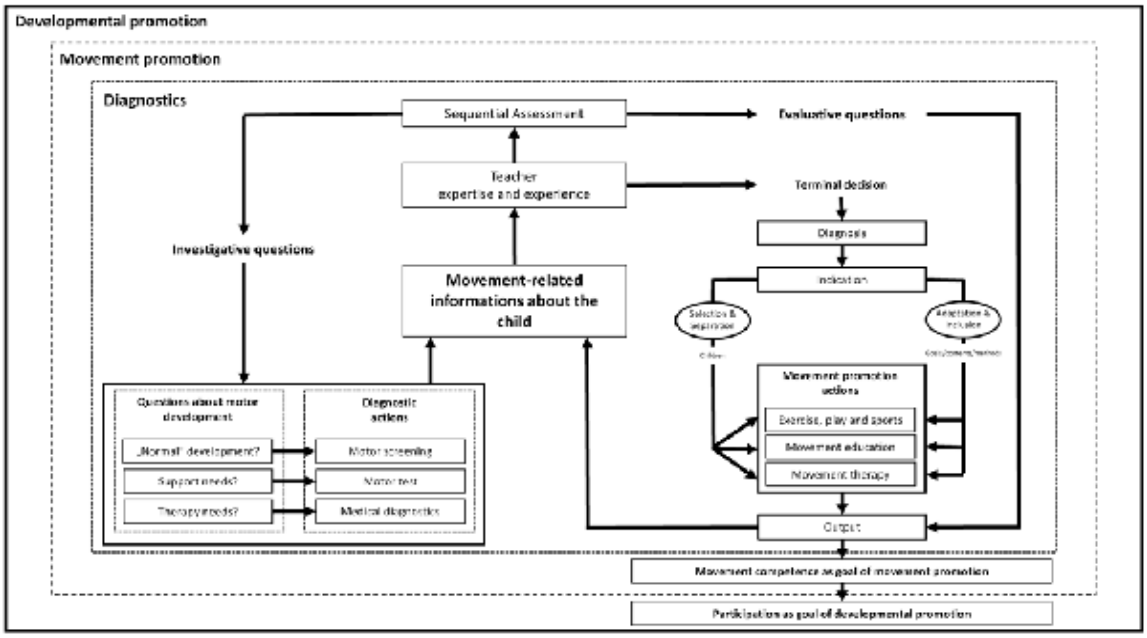


***Figure 1:*** *Sequential diagnostic strategy [12].*

Screenings, like all other test procedures, are subject to various psychometric properties. These include objectivity, reliability and validity. Testing and compliance with these criteria is considered indispensable. It should be easy and quick for the user to learn how to use a (motor) test. A screening should be quick to carry out and cost little money (material and personnel). Here, a time span of maximum 15 to 30 minutes is specified for the implementation; the costs in relation to the benefit must be reasonable [13]. In addition to these psychometric properties, diagnostic validity is an important criterion of screenings [14]. Sensitivity and specificity, among others, best describe the ability of a test to classify someone as "normal" or "not normal" [15,16]. In the field of developmental diagnostics, a high sensitivity is required in order to detect even slight abnormalities in a screening [9]. A test with high specificity is more likely to be used to confirm a diagnosis. To achieve an optimal balance between sensitivity and specificity, a ROC (Receiver Operating Characteristic) analysis is used to determine a cutoff value [17]. The AUC (Area Under the ROC-Curve) describes the area under the ROC curve and provides a sensitivity index independent of the cutoff value [18]. Because of the high importance of screenings in the context of the sequential diagnostic strategy, the present study aims to examine whether or how many motor screenings exist for kindergarten children and whether they meet the required psychometric properties.

## Methods

The review follows the PRISMA checklist and was conducted in June and July 2021. Steps not relevant to this review were excluded [19]. The review was conducted in three steps: Inclusion or exclusion of articles, review of relevance and selection of articles designated as motor screening, and search for additional sources using the literature lists of included articles and using online searches.

*Search strategy:* The literature search was conducted for articles validating or investigating motor screening for children aged three to six years and published in English, German, Spanish or French up to June 2021. For this purpose, the electronic sources Dialnet, ERIC, PSYNDEX, PubMed and SpoLit were systematically searched.

The following keywords were generated and combined for this purpose:

(a) *Kindergarten/ preschool/ école maternelle/ escuela primaria* or *Elementarerziehung/ elementary education/ éducation élémentaire/ educación elementaria* or *Kinder/ children/ enfants/ ninos* and

(b) *screening* and

(c) *motorische Fähigkeiten/ motor ability/ capacités motrices/ habilidades motrices* or *motorische Fertigkeiten/ motor skills* or *motorische Kompetenz/ motor competence/ compétence motrice/ competencia motriz* or *motorische Qualifikationen/ motor qualification/ qualification du moteur/ calificación del motor* or *Mobilität/ mobility/ mobilité/ movilidad*.

***Screening and selection criteria:*** The article search and removal of duplicates was conducted according to the following inclusion criteria: (a) target age group three to six years, (b) screening based on motor abilities/ skills/ competencies/ qualifications or mobility, and (c) publication in English, French, German or Spanish. Reviews and validation studies were included. The included articles were screened for eligibility in the next step. Only articles that provided relevant information or results on the psychometric quality of the current version

of the test procedures were selected. The literature lists of the articles were searched for further references that could provide relevant information on the test procedure.

***Data extraction:*** The descriptive and psychometric properties of the procedures were extracted from the selected articles and related publications for qualitative synthesis. The presentation of the characteristics of the test procedures includes name(s) of author(s), year of publication (if applicable, test version), age of the target group, number of test items and underlying construct, as well as information on the common test quality criteria relevant for screenings (objectivity, reliability, validity, diagnostic validity and economy).

***Quality of psychometric properties:*** In accordance with the standards for psychometric characteristics of test procedures by AERA et al. [20], it is determined which test quality criteria were checked in the various test procedures and how these are to be classified in terms of their quality. Objectivity, internal consistency, test-retest reliability, content validity, construct validity, criterion validity and additionally the diagnostic validity (sensitivity, specificity, AUC) are taken into account. Evaluation of the test objectivity adapted from Clarke [21], of reliability adapted from Ballreich [22], of validity adapted from Mangold [23], and Weise [24], of sensitivity adapted from Meisels [25], and of AUC adapted from Hosmer and Lemeshow [26]. Bös, Schlenker, Büsch et al. [27] evaluate the criteria of economy using a scale from 0 to 3 points per criterion. The more economic a criterion, the more points are awarded. In total, a test procedure can receive a maximum of 12 points for its economy. In order to be able to form an overall judgement of the different test procedures, a result of 12 to 11 points is considered excellent, a result between 10 and 8 is considered very good, 7 to 5 corresponds to medium, 4 to 2 moderate and 1 to 0 low.

## Results

A total of 1013 publications were found using the selected keywords. After removing the duplicates and checking the articles for suitability, 557 publications were included in the further analysis. In the process, 21 potential screenings were found. The following figure 2 gives an overview of the process of the analysis.

Eight tests have data on objectivity, whereby only three are in the excellent range. Information on internal consistency can be found in 12 tests, on test-retest reliability in 14, with four procedures in the excellent range. Content validity was tested for five procedures, criterion validity for 12 and construct validity for nine. Information on diagnostic quality (sensitivity and specificity or AUC) is found for ten tests, seven of which can be regarded as excellent and one as low; a cut-off value is given for nine. Seven methods fulfil all the criteria required for screening, while three methods do not provide any information on psychometric properties.

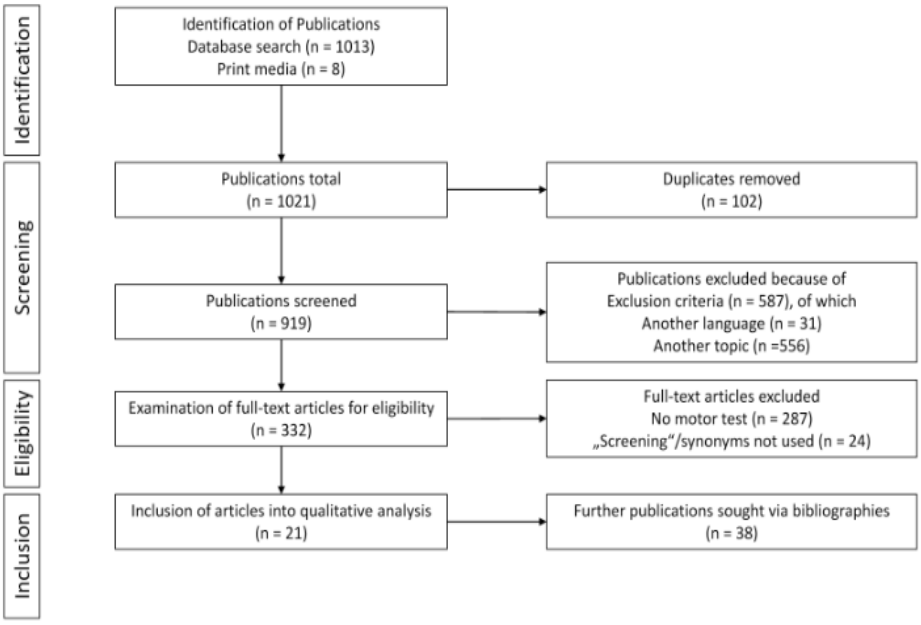


***Figure 2:*** *PRISMA flow diagram of the study.*

**Table 1** shows the procedures found during the research, which are referred to as screening in the sources. In addition to the names in short form, author(s), year and target group, are listed as well as additional sources found that document a validation of the respective procedure, including the psychometric properties that were evaluated.

*Note: * = motor subscale of the respective test battery*

***Table 1:*** *Overview of the procedures found that are referred to as screening: Test names (references), age groups in years, number of validation studies (studies) and psychometric properties.*

| Test (reference), age group (years) | Studies | Psychometric properties |
|---|---|---|
| BDI-2 Screening* (28), 0-7 | 2 | Int. Cons.: .98-.99; Reliability: .80 (retest); Validity: .64-.76 (criterion); Expert opinion (content); Sensitivity/Specificity: .94/.31; Cutoff: 1,5 SD; Economy 3-4 (Orga: 0, Room: 2-3, Time/Pers.: 0, Material: 0-1) |
| BBK 3-6* (29), 3-6 | 0 | Objectivity: .91-.94; Int. Cons.: .89-.91; Validity: Expert opinion (content); EFA (construct); School readiness*** (criterion); Cutoff: Standard value < 90; Economy: 6-7 (Orga: 0, Room: 3, Time/Pers.: 1, Material: 2-3) |
| BIKO 3-6* (30), 3-6.5 | 0 | Objectivity: .61-.75; Int. Cons.: .77; reliability: .70 (retest); Validity: Expert opinion (content); EFA (construct); .78-.80 (criterion); .40-.53 (prognosis); Sensitivity/Specificity: .85/-; Cutoff: 16. Percentile; Economy: 6 (Orga: 1, Room: 3, Time/Pers.: 2, Material: 0) |
| BOT-2-BF (31), 4-14 | 2 | Reliability: .90-.97 (retest); Validity: Raschanalysis; Sensitivity/Specificity: .84/.43; AUC: .48; Economy: 6 (Orga: 0, Room: 3, Time/Pers.: 0, Material: 3) |
| BRIGANCE Screens III F&1* (32), 0-7 | 9 | Objectivity: .90-.99; Int. Cons.: .84-.99; Reliability: .84-.99 (retest) Validity: EFA (construct); Expert opinion (content); .66-.97 (criterion); Sensitivity/Specificity: .82/.84; Cutoff: ROC for every age group; Economy: 6-7 (Orga: 0, Room: 2-3, Time/Pers.: 1, Material: 3) |
| BUEVA-III* (33), 4-6.5 | 0 | Int. Cons.: .82-.84; Validity: .17-.76, EFA (construct); .08-.49(criterion); .52 (prognosis); Sensitivity/Specificity: .65-.75/.73-.78; Cutoff: T<40; Economy: 8 (Orga: 0, Room: 3, Time/Pers.: 2, Material: 3) |
| DDST* (34), 0-6 | 4 | Objectivity: .90; Reliability: .96 (retest); Validity: .97 (criterion); Sensitivity/Specificity: 1.00/.92; AUC: .92/.97; Economy: 6 (Orga: 0, Room: 3, Time/Pers.: 2, Material: 1) |
| DITKA (35), 5-10 | 0 | Economy: 11 (Orga: 3, Room: 3, Time/Pers.: 2, Material: 3) |
| Early Screening Profiles ESP* (36), 2-6 | 2 | Int. Cons. :68; Reliability: .66 (retest); Validity: .48-.84 (criterion); .60-.70 (construct); Economy: 2-3 (Orga: 0, Room: 2-3, Time/Pers.: 0, Material: 0) |
| FirstSTEp* (37), 0-6 | 0 | Int. Cons.: .65-.75; Reliability: .85 (retest); Sensitivity/Specificity: .80/.80; Cutoff: 1,5 SD; Economy: 2 (Orga: 0, Room: 2, Time/Pers.: 0, Material: 0) |
| HamMotScreen (38), 4-7 | 0 | Economy: 7 (Orga: 3, Room: 1, Time/Pers.: 1, Material: 2) |
| KMS 3-6 (39), 3-6 | 0 | Reliability: .80-.90; Validity: .10-.60; Economy: 7 (Orga: 3, Room: 2, Time/Pers.: 1, Material: 1) |
| Kleine Hexe (40), 4-8 | 0 | Economy: 5-7 (Orga: 1, Room: 2-3, Time/Pers.: 0, Material: 2-3) |
| M-ABC-2 (41), 3-16 | 8 | Objectivity: .79; Int. Cons.: .62-.67; Reliability: .80 (retest); Validity: CFA (construct); .40-.49 (criterion); Economy: 2-3 (Orga: 0, Room: 2-3, Time/Pers.: 0, Material: 0) |
| McCarthy ST* (42), 4-6.5 | 3 | Int. Cons.: .33-.72; Reliability: .68-.80 (retest); Validity: .22-.26 (criterion); Cutoff: 10. Percentile; Economy: 5-6 (Orga: 0, Room: 3, Time/Pers.: 0, Material: 2-3) |
| MobiScreen 4-6 (43), 4-6 | 4 | Objectivity: .92-.96; Int. Cons.: .60; Reliability: .93 (retest); .68-.76 (paralleltest), Validity: EFA, CFA (construct); .23-.72 (criterion); Sensitivity/Specificity: .80-1.00/.68-76; AUC: .82-.91; Cutoff: ROC for every age group; Economy: 11 (Orga: 3, Room: 3, Time/Pers.: 3, Material: 2) |
| MOT 4-8 Screen (44), 4-8 | 0 | Objectivity: .98; Int. Cons.: .79; Reliability: .82 (retest); Validity: .79-.80 (criterion); Sensitivity/Specificity: .80/.74; Cutoff: Motor Quotient < 85; Economy: 10 (Orga: 3, Room: 3, Time/Pers.: 2, Material: 2) |
| NEPSY-II* (45), 3-16 | 0 | Objectivity: .93-.99; Reliability: .70-.91 (split-half); .21-.91 (retest); Validity: CFA (construct); .34-.39 (criterion); Literature analysis (content); Cutoff: 6. Percentile; Economy: 5 (Orga: 0, Room: 3, Time/Pers.: 2, Material: 0) |
| Pfiffigunde (46), 5-8 | 0 | Objectivity: Standardized Instruction; Validity: Expert opinion (content); Economy: 3-4 (Orga: 1, Room: 2-3, Time/Pers.: 0, Material: 0) |
| Stay in step Screening Test* (47), 5-7 | 0 | Reliability: .87-.90 (retest); Economy: 5-7 (Orga: 1, Room: 2-3, Time/Pers.: 0, Material: 2-3) |
| TGMD-3 (48), 3-10 | 4 | Objectivity: .94; Int. Cons.: .93; Reliability: .92 (retest); Validity: .33-.47 (criterion); CFA (construct); Sensitivity/Specificity: .71-.76/.91; AUC: .86-.87; Cutoff: 85/90; Economy: 8-9 (Orga: 3, Room: 2, Time/Pers.: 2, Material: 1-2) |

## Discussion

The present study investigated whether and which motor screenings are available for children of kindergarten age. By searching in four different languages (German, English, French, Spanish), 21 procedures were found that are described as screening. In the case of screening batteries that are intended to capture the whole developmental stage of the child, only the test part that concerns motor development was singled out for analysis.

*Use of the term "screening":* Reichenbach [49] refers to the procedure "Die Abenteuer der kleinen Hexe" [40] as screening, but this term does not appear in the manual of the tests. The DDST is defined as a screening by the authors already in the naming. Here, reference is made to the fact that a screening can be learned, carried out and evaluated quickly and easily, thus revealing a developmental delay [34]. This corresponds to the criterion of simplicity according to Stangler et al. [13]. In the procedure "Diagnostik mit Pfiffigunde" one finds the concept of screening [46]. However, this procedure describes, among other things, that the extent, strength and profile of the disorder are determined, as well as an age-appropriate development of gross and fine motor skills and the state of lateral development [46]. However, a screening only has the task of roughly deciding between "normal" and "not normal" [9]. In DITKA, the authors say that the six core tasks can give a rough overview in the sense of a screening test [35], which corresponds to the criterion of classification according to Esser and Petermann [9]. In the case of BBK 3-6, Frey et al. [29] point out that this is a screening procedure that provides an insight into strengths and weaknesses and where further, more detailed diagnostics with targeted support based on this are recommended. This is fully in line with the filtering function of screenings in the sequential diagnostic strategy [7,8,11). Franzen and Berg [50] describe NEPSY-II in its previous version as a screening. Korkman et al. [45] use this term too in this pre-

vious version. MobiScreen 4-6 [43] and MOT 4-8 Screen [44] already indicate in their names that they are screenings. Both have been shown to fulfil the required criteria to a reasonable degree and can be described as screening. The authors of the BIKO 3-6 describe it as a developmental screening [30]. This also fulfils the required criteria to be considered a screening, but to a lesser extent than the two aforementioned methods. KMS 3-6 by Bös et al. [39] is declared as a screening but there do not exist the criteria of diagnostic validity.

*Verification of the psychometric properties:* If one looks at the economy, only a few procedures indicate a low time and personnel requirement [30,33-35,43-45,48]. In this context, if one looks at the implementation time of the different procedures, it is noticeable that most of them take a lot of time, as does the organisation, often in small groups or individual situations. This contradicts the guidelines of Lienert and Raatz [51] that a screening should be quick and easy to carry out with little effort. Many methods have very good to excellent values for the space required and the choice of equipment [29,31-33,35,40,42-44,47], which is also of great importance for the users (51). It is noticeable that there is no information on the main psychometric properties for three procedures [35,38,40], and only partial information for two procedures, which is also an indispensable prerequisite for screenings [52]. Only nine procedures were tested for objectivity, reliability and validity [29,30,32,34,41,43-45,48]. For all other procedures currently in use, this information should be provided in studies. The diagnostic validity required by Marx and Lenhard [14], by which children are to be classified as "normal" and "not normal", is lacking in almost all procedures. Only ten screenings were tested for their diagnostic quality and provide information on sensitivity and specificity or the AUC [28,30-34,37,43,44,48]. Ten methods provide information on the determination of a cut-off value [28-30,32,33,37,43-45,48]. However, the approach is very different: The cut-off value for BDI-2 [28] is 1.5 standard deviations and has an excellent sensitivity. In the BIKO 3-6 [30], the 16th percentile is described as the cut-off value, as it is specified, for example, in the UEMF guidelines [53]. In this procedure, the cut-off value also has an excellent sensitivity. The McCarthy ST [42] gives the 10th percentile for this, but does not give any information on sensitivity. The MOT 4-8 Screen [44] relies on a motor quotient of less than 85 as a cut-off value with a very good sensitivity. Only two methods [32,43] determine the optimal cut-off value via an ROC analysis and both also achieve an excellent sensitivity and follow the indications of Pospeschill [17] to achieve an optimal balance between sensitivity and specificity. The TGMD-3 [48] provides a cut-off value in the form of a raw value, which, however, apparently shows a very good sensitivity. In addition, the method has information on the AUC and here follows the information of Reineking and Schröder [18]. Only those methods for which information on diagnostic quality is found in addition to the main quality criteria should continue to be referred to as screening. In summary, BRIGANCE [32], DDST [34], MobiScreen 4-6 [43], MOT 4-8 Screen [44] and TGMD-3 [48] provide information on all the quality criteria required for screening; the procedures hardly differ from each other in the quality of their psychometric properties and can all be rated in the very good to excellent range. They differ only in their economy and in the underlying construct.

## Conclusion and prospects

In this research, 21 procedures were found that are described as screening. Seven procedures meet all the required criteria to a high degree, all others cannot be described as screening due to missing psychometric properties. Many of these procedures are quite complex to use and do not have any information about the common psychometric properties. Since in a sequential diagnostic strategy, a screening procedure should first be used to decide whether detailed diagnostics should be carried out because of a "not normal" test result, such a procedure must be used. In this way, the children in a kindergarten group can be tested quickly and easily for "normal" motor development. The procedures mentioned are based on different concepts. Due to their economy, MobiScreen 4-6, MOT 4-8 Screen and TGMD-3 are particularly recommended.

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**Biographic notes:** Dr. Andrea Dincher is a lecturer for special tasks at the Institute of Sports Science at Saarland University and is responsible for the training of prospective primary school teachers in the subject of physical education. Her research focuses on the motor development of early and middle childhood and the associated test development and motor promotion programs. Another focus is on movement therapy for neurological diseases. She is a volunteer in the German Sports Teacher's Association Saar (president) as a consultant for the state sports association and has been working as a trainer for children, seniors and special groups in a sports club for over 25 years.

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