The effect of ball features on health risks in competitive children and youth football conducted by the Friedrich-Alexander University Erlangen-Nuremberg (Condensed Version)

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1. Introduction

There has been an ongoing discussion about the risks of heading in football over the past decades focusing on the risk of concussion during games, negative long-term effects of consecutive heading and the protection of the head. However, most of these studies investigated an adult population but not the possible risks for children. Furthermore, these studies focused on concussions while other health risks due to the ball itself were often excluded from the scope. To give a sound statement on the influence of ball features on various factors of children’s health in football, a systematic analysis and review of the current state of research based on internationally accepted standards is needed.

Here, various features of the ball need to be taken into account in order to show the whole picture. These features are the size of the ball, the weight of the ball, ball pressure, the ball’s texture and its rate of absorbing water in wet weather conditions (cf. Figure 1).

Looking at how physiology and technique in football are developed, these two have a clear pathway of how to be taught. Subcategories such as the size of the pitch, the size of the goal, the number of goals, the number of players, substitution systems, the duration of the game, the system of rules and the form of organization (cf. Figure 2) impact the periodization. Hence, they are being used at a certain age or at a certain level of skill. The same holds true for parameters of the ball, as mentioned above. Children should play with a ball that is appropriate for their age and skill level (Wein, 2016).
Horst Wein (2016) named 25 reasons why children should use age appropriate balls for their football development (cf. Figure 3), which can be further divided into three categories such as tactical development, technical development and health development.
2. Methods

The systematic review of the existing literature followed the guidelines of the Cochrane handbook for systematic reviews (Higgins, 2016). Here, a three phase process consisting of generating the keyword list for the literature research, screening the identified literature based on predefined criteria and the qualitative analysis of the remaining literature was conducted.

Figure 4 shows the analysis scheme of the systematic literature review according to the Flow Diagram of Moher et al. (2009), conducted by the scientists at the Department for Sport and Sport Science at the Friedrich-Alexander University Erlangen-Nuremberg in Germany. In the process of identifying relevant papers, 203 records were found, 34 of which ultimately were classified eligible for full-text analysis (cf. Figure 6).
Going into greater detail, Figure 5 shows the list of key words which were chosen to search for valid records in databases such as Pubmed, Scopus and google scholar, representing categories such as language, health threats, ball features, long-term effects on bio-medical health and demographic.
After the records were screened, 34 records fulfilled the criteria for eligibility and were taken into full-text analysis.

Here, criteria from van Tulder (2003) were applied in order to give a qualitative analysis of the 34 records, 2 of which had to be excluded due to poor quality and difficulty to retrieve. Figure 6 shows the qualitative criteria that all 32 records were analyzed by.
3. Results

All in all, the epidemiological data, i.e. the studies that report on past events such as recorded and cataloged data are not useable to address the question what effect ball features have on the health risk in competitive children and youth football. Hence, only three studies with theoretical data and some minor experimental trials within them are shown in the following section. Figure 7 shows all results after the qualitative criteria were applied.
<table>
<thead>
<tr>
<th>Studies</th>
<th>Study Design</th>
<th>Timing</th>
<th>Methodological Quality</th>
<th>Sample Size</th>
<th>Age of Participants</th>
<th>Drop out rate</th>
<th>Control Group</th>
<th>Number of Trials</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babbs, C. F. (2017).</td>
<td>theoretical calculation</td>
<td>retrospective medium</td>
<td>theoretical</td>
<td>9 years - adult</td>
<td>none</td>
<td>none</td>
<td>theoretical</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Boyd, K. T., Brownson, P., &amp; Hunter, J. B. (2001).</td>
<td>descriptive</td>
<td>prospective medium</td>
<td>n=28</td>
<td>0-15 years</td>
<td>none</td>
<td>none</td>
<td>clinical data</td>
<td>p=0.039; p=0.027</td>
<td>none</td>
</tr>
<tr>
<td>Brophy, R. H., et al. (2015).</td>
<td>review</td>
<td>retrospective medium</td>
<td>n=55</td>
<td>collegiate - adult</td>
<td>none</td>
<td>none</td>
<td>review</td>
<td>p=0.045; p=0.05</td>
<td>none</td>
</tr>
<tr>
<td>Deneori, R. A. (2012).</td>
<td>review</td>
<td>retrospective medium</td>
<td>n=26</td>
<td>college</td>
<td>none</td>
<td>none</td>
<td>review</td>
<td>none</td>
<td>none</td>
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<tr>
<td>Lukášek, M., &amp; Kalichová, M. (2015).</td>
<td>laboratory study</td>
<td>cross-section poor</td>
<td>16</td>
<td>10</td>
<td>none</td>
<td>3 ball speeds</td>
<td>1</td>
<td>n.s.</td>
<td>none</td>
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<tr>
<td>Macgregor, D. M. (2003).</td>
<td>epidemiological study</td>
<td>retrospective medium</td>
<td>187 (120 soccer)</td>
<td>6-13 (M = 10.7)</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Monfort, S. M., et al. (2015).</td>
<td>epidemiological study</td>
<td>retrospective medium</td>
<td>995</td>
<td>highschool</td>
<td>none</td>
<td>none</td>
<td>p &lt; .05</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Naunheim, R. S., et al. (2000).</td>
<td>field experiment</td>
<td>cross-section poor</td>
<td>small</td>
<td>highschool</td>
<td>none</td>
<td>Am. Football, hockey, soccer</td>
<td>p &lt; .001</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>O’Kane, J. W., et al. (2014).</td>
<td>cohort study</td>
<td>prospective high</td>
<td>351</td>
<td>11-14 years</td>
<td>7,60%</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
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<tr>
<td>O’Kane, J. W. (2016).</td>
<td>review</td>
<td>retrospective high</td>
<td>310</td>
<td>n.a.</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
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<tr>
<td>Paterson, A. (2009).</td>
<td>review</td>
<td>retrospective high</td>
<td>none</td>
<td>n.a.</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
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<tr>
<td>Pickett, W., et al. (2005).</td>
<td>epidemiological study</td>
<td>retrospective medium</td>
<td>1714</td>
<td>10-24 years</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Queen, R. M., et al. (2003).</td>
<td>theoretical calculation</td>
<td>retrospective high</td>
<td>theoretical</td>
<td>6-9 years</td>
<td>none</td>
<td>theoretical</td>
<td>none</td>
<td>none</td>
<td>theoretical</td>
</tr>
<tr>
<td>Reed, W. F., et al. (2002).</td>
<td>field study + control group</td>
<td>prospective medium</td>
<td>21</td>
<td>13-16 years</td>
<td>none</td>
<td>30</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Rössler, R., et a. (2016).</td>
<td>epidemiological study</td>
<td>prospective medium</td>
<td>none</td>
<td>7-12 years</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Shawchenko, N., et al. (2005).</td>
<td>numerical model + lab. data</td>
<td>n.a.</td>
<td>high</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Tierney, R. T., et al. (2004).</td>
<td>laboratory experiment</td>
<td>n.a.</td>
<td>high</td>
<td>40</td>
<td>20-30 years</td>
<td>none</td>
<td>none</td>
<td>p &lt; .05</td>
<td>none</td>
</tr>
<tr>
<td>Timpka, T., Risto, O., &amp; Björnslöf, M. (2008).</td>
<td>descriptive epidemiological study</td>
<td>retrospective good</td>
<td>1800</td>
<td>13-16 years</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Witol, A. D., &amp; Webb, R. M. (2000).</td>
<td>cross-section/retrospective study</td>
<td>retrospective high</td>
<td>n=72</td>
<td>highschool and adults</td>
<td>0</td>
<td>matched but smaller</td>
<td>none</td>
<td>none</td>
<td>none</td>
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<tr>
<td>Wilmot, E., et al. (2009).</td>
<td>retrospective cohort study</td>
<td>retrospective medium</td>
<td>none</td>
<td>n.a.</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Zuckerman, S. L., et al. (2012).</td>
<td>literature review</td>
<td>retrospective good</td>
<td>n=40</td>
<td>n.a.</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>
Shewchenko et al. (2005) use a numerical model in combination with laboratory data to describe the increase of linear head acceleration when the player’s head comes into contact with the ball, when ball mass increases through the absorption of water (cf. Figure 8) or through increased ball pressure (cf. Figure 9).

![Figure 8: Numerical Model from Shewchenko et al. (2005), p.i35](image8)

![Figure 9: Numerical Model from Shewchenko et al. (2005), p.i35](image9)
Queen et al. (2003) use another theoretical calculation in order to describe how linear head acceleration increases using a size 3 ball at 12 psi inflation at various speeds. Three different head masses are illustrated in Figure 10. The lower the head mass of the player, the higher its linear acceleration while maintaining constant size and inflation of the ball.

Babbs (2017) uses another theoretical calculation to show sampling distributions for head acceleration. Ultimately, accelerations of the head, are experienced to be greater by children than those experienced by adults. The soccer ball which is currently used in youth soccer, does not make up for the difference in size, weight and pressure of young players. “However, a modified size 4 ball can make heading as safe for children as it is for adults” (Babbs, 2017) Figure 11 shows three different types of balls and the respective mean head acceleration they cause.
4. Conclusion

To conclude, it can be stated that parameters such as the weight, size and inflation of the ball as well as its capability to absorb water do have an effect on the health risks in children and youth football. However, due to the lack of conclusive epidemiological studies, the conclusions made are based on theoretical calculations only and therefore experimental studies with a high methodological quality are highly recommended. These studies would then allow a detailed insight into the true epidemiological effects of individual parameters on children and youth players and would allow further efforts to be made to reduce these injury risks.

Figure 11: Head velocity change from Babbs (2017), p.9
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