# Timetabling Belgian youth field hockey competitions with an incomplete round robin tournament

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**Keywords:** Sports scheduling, Matheuristic, Incomplete round robin.

## 1 Introduction

Field hockey in Belgium is rapidly growing in popularity. The recent success of the national hockey team (world champions in 2018, European champions in 2019 and Olympic gold in 2020) overwhelmed the Royal Belgian Hockey Association (RBHA) with a multitude of new clubs and an increased number of entries. Therefore, the construction of adequate schedules for hockey youth competitions has become increasingly more challenging.

Currently, teams are partitioned into leagues. The leagues are formed based on the travel time between the home venues of the teams, a problem that is known as the sports team grouping problem [4]. Given the assignment of teams to leagues, a schedule is constructed for each league with the objective of minimizing the number of venue capacity violations. This problem is also known as the multi-league sports scheduling problem [1,2].

Although this approach is widely used in practice, it also has some limitations. First, because these problems are handled sequentially, prioritizing travel times means that capacity violations often cannot be avoided. A solution method to integrate the partitioning and scheduling problems is proposed in [3]. Second, the requirement that teams can only face teams from the same league restricts the solution space. Although a solution might be found that performs well with respect to total travel time, close neighbors are sometimes partitioned into different leagues, leading to much disbelief by the teams.

In this extended abstract, instead of partitioning teams into leagues, we propose to allocate teams to one league only. Typically, the size of this league is too large to fit a round robin tournament. To resolve this issue, teams play a fixed number of games in which they can face any subset of the opponents. Hence, this format is called an incomplete round robin tournament and greatly extends the solution space, providing opportunities for reducing travel times.

## 2 Problem description

We consider hockey youth competitions of age categories under 7, 8, and 9 in the first half of the 2023/2024 season. Each age category is further split into a boys and girls

competition. Moreover, each team is characterized by a strength level ranging from 1-3. This results in 18 categories, including 11 to 93 teams with a total of 808 teams. Each match is played at the home venue of one of the two teams. Whether a team plays home or away in a round is given by its home-away pattern (HAP).

Each club has a limited number of fields that are, in each round, available during a limited number of hours. The RBHA imposes that venue capacity requirements should be strictly met: a timetable should not require a club to host more matches than it physically can. As teams from the same club are often scattered over multiple categories, it is not possible to schedule the categories independently from each other without violating some of these constraints. Other constraints are that the same opponent can be seen at most twice: once at home and once away, the number of home and away games of each team should be balanced and three consecutive home or three consecutive away games are forbidden. Moreover, teams cannot see the same opponent twice in four consecutive slots and can have at most one bye. Finally, the objective is to reduce total travel time.

## 3 Solution approach and preliminary results

Since a single IP formulation to schedule all youth competitions simultaneously turns out too large to handle by CPLEX, we develop a fix-and-optimize based matheuristic. Neighborhoods are constructed by fixing either all variables related to teams from a subset of categories or all variables related to a subset of time slots. Next, a percentage of the HAPs is fixed for each neighborhood, depending on how difficult the neighborhood is to solve. Moreover, each neighborhood starts with a time limit of one minute. However, time limits are extended to five minutes for promising neighborhoods that are harder to solve. Neighborhoods are chosen based on repeatedly solving multi-armed bandit problems. We avoid being trapped in a local optimum by freeing a subset of the variables and maximizing the number of variables that can be changed from this set, while still guaranteeing feasibility.

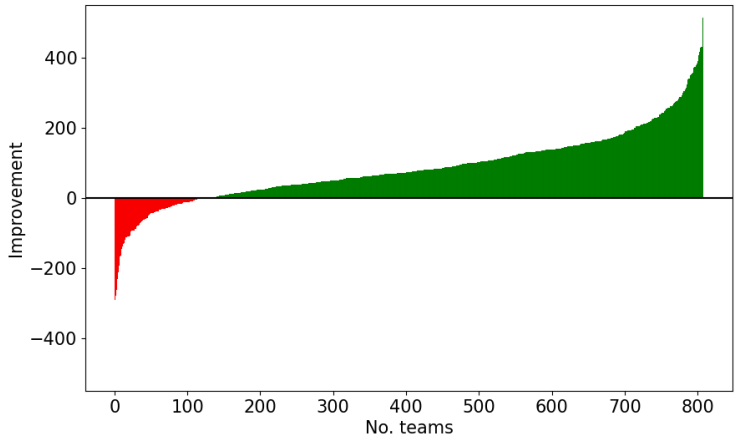
The proposed matheuristic is able to find a solution with a total travel time of 166,666 minutes (<1.5% of best found integer bound) in a reasonable time (12h). In contrast to the original schedule, all venue capacities are satisfied. Our approach also manages to reduce the total travel time by 25%, which corresponds to more than 971 hours. In total, 644 of the 808 teams are better off: the improvement in individual travel time of the teams are given in Figure 1.

Although the situation improves for most of the teams, we see that some teams are also considerably worse off. This is not surprising, as we only look at total travel time at the moment. Therefore, we are currently working on an approach that distributes travel times more fairly over the teams. The RBHA is very positive about our work and will adopt the incomplete round robin tournament in the second half of the 2023/2024 season.

## References

1. Davari, M., Goossens, D., Beliën, J., Lambers, R., Spieksma, F.C.: The multi-league sports scheduling problem, or how to schedule thousands of matches. Operations Research Letters **48**(2), 180–187 (2020)

Fig. 1: Distribution of the improvement in team's travel time (in minutes) compared to the original schedule




Green depicts a reduction in travel time, while red depicts an increase in travel time, compared to the original schedule used for the first half of the 2023-2024 season.

2. Li, M., Davari, M., Goossens, D.: Multi-league sports scheduling with different leagues sizes. Eur. J. Oper. Res. **307**(1), 313–327 (2023)
3. Li, M., Goossens, D.: Grouping and timetabling for multi-league sports competitions. In: Proceedings of the 13th International Conference on the Practice and Theory of Automated Timetabling-PATAT 2022. vol. 3, pp. 192–194 (2022)
4. Toffolo, T.A., Christiaens, J., Spieksma, F.C., Vanden Berghe, G.: The sport teams grouping problem. Annals of Operations Research **275**(1), 223–243 (2019)