In this study, a model for the dynamics of nandrolone, an anabolic steroid, in human body is constructed. Firstly, the model generates the dynamics of nandrolone only and its metabolites in the body. Secondly, we design different scenarios to see how nandrolone users can cheat in performance enhancing drug (PED) tests. PED tests for nandrolone check for the presence of 19-NA. Thus, to cheat the tests, PED users typically also use inhibitors of 19-NA such as Finasteride, a drug primarily used to cure male balding and prostate growth. Actually, Finasteride does not have a direct effect on 19-NA; its main effect in the body is the inhibition of enzymes that turn nandrolone into its metabolite 19-NA. Accordingly, we include structures for Finasteride and reductase enzymes in the model.

Figure 1: Simplified Model Structure

Injection Site, Finasteride in Blood, NA in Blood, NE in Blood and Reductase Enzymes are the key variables that we are interested in. Model validation is carried out by utilizing three runs and comparing the results to literature. The first run involved no intake of nandrolone and finasteride. Second run involved the injection of 150 mg of nandrolone decanoate. The results of the run and the comparison to real data can be seen in figure 2 and figure 3. Third run is done by intake of 5mg of...
finasteride with the injection of 150 mg nandrolone decanoate. The model-generated dynamics are consistent with the reviewed literature.

![Figure 2: Behavior Validity Run](image2)

![Figure 3: Real Data for Comparison](image3)

We test different ways of cheating the PED tests using scenario analyses with Finasteride. An example scenario can be seen in figure 4.

![Figure 4: A False Negative Scenario Example](image4)

Our scenarios showed that besides decreasing 19-NA excretion, finasteride also decreased the 19-NA/19-NE (another metabolite of nandrolone) ratio, one of WADA’s security measures. To get around this effect, WADA should take frequent samples during the competitions. If any sample has an increasing 19-NA/19-NE ratio, WADA should flag the sample and closely follow that athlete. Alternatively, a threshold for 19-NE can be considered. False positive cases can be implemented into the model in future work. Model can also be modified to account for other similar anabolic steroids.
REFERENCES

7. Schanzer W., Geyer H., Nolleertning E., Finasteride-A Substance for Manipulation in Dope Control. Recent Advances in Doping Analysis(7); 1999
11. Geyer H., Gorius I., Dreyer N., Mareck U., Thevis M., Schanzer W. Investigation about the effects and the detection of finasteride. Recent advances in doping analysis (13); 2005