**Table 1.** Types, mechanisms, and functions of post-translational modifications of proteins

|  |  |  |
| --- | --- | --- |
| PTM | Machine made | Feature |
| phosphorylation | ATP phosphate groups are transferred to specific sites on proteins by phosphorylated kinases | Regulates nearly all aspects of cellular processes, from cell signaling, signal transduction, cell cycle, resilience to growth and development (Singh et al., 2017) |
| glycosylation | By covalent attachment of glycans to amino acid functional groups | Involved cell signal transduction, the screening of biomarkers, which affects the spatial conformation, activity and localization of proteins (Schjoldager, Narimatsu, Joshi, & Clausen, 2020) |
| ubiquitination | Protein abundance is controlled by ubiquitinating and deubiquitinating enzymes mediating protein degradation and stability | Virtually every process in the cell is regulated by the ubiquitin system, from the cell cycle to cell migration, invasion, apoptosis, differentiation, and so on (Samaržija, 2021) |
| acetylation | It is mainly the process of acid anhydride or acid reaction with alcohol to produce ester | It is an important epigenetic marker that regulates cells' response to inflammation and maintains cellular status (Shvedunova & Akhtar, 2022) |
| methylation | Methyltransferase catalyzes the production of S-adenosylmethionine | It is involved in chromosome assembly, protein and nucleic acid transport and metabolism, intracellular signaling, etc (Jakobsson, 2021) |
| succinylation | The process of transferring succinyl-CoA to proteins by succinylase | It is involved in metabolic regulation and affects the function of mitochondrial proteins and metabolic pathways (Yang & Gibson, 2019) |
| lipidation | Proteins are covalently attached to hydrophobic lipid molecules after ribosome synthesis | The lipid chain has a good compatibility with the biolipid membrane, and the protein is fixed on the cell membrane (Y. Zhang, Qin, Sun, Chu, & Zhou, 2021) |
| lactylation | Lysine residues on histones were modified with lactic acid as substrate | Participate in glycolysis, regulate cell cycle and cell proliferation, macrophage polarization, blood vessel function, mitochondria, nervous system regulation and other important life activities (A. N. Chen et al., 2021) |

**Table 2**. Summary of studies on the effects of protein phosphorylation on diagnosis, treatment, and prognosis of prostate cancer

|  |  |  |  |
| --- | --- | --- | --- |
| protein | Phosphorylation site | significance | reference |
| ABI2 | Ser-183 | PIM1-phosphorylated ABI2 promotes tumor invasion, and PIM inhibitor therapy significantly reduces intramuscular PCa invasion | (Jensen et al., 2023) |
| AKT | Thr-305, Thr-309, Ser-472, Ser-473, Ser-474, Thr-308, Tyr-474 | Uncovering the occurrence and development mechanisms of PCa, providing potential targets and possible drugs for the treatment of prostate cancer, and providing solutions to PCa cross-resistance | (Chang et al., 2021; C. P. Liao et al., 2018; L. Liu et al., 2023; M. Liu et al., 2023; Turkekul, Colpan, Baykul, Ozdemir, & Erdogan, 2018) |
| AR | Ser81, Ser213, Tyr534 | Providing potential targets and possible drugs for the treatment of PCa | (X. Gao et al., 2021; Kuo et al., 2019; H. P. Lin et al., 2019) |
| YAP1 | Thr-119, Thr-154, Thr-412, Ser-138, Ser-367, Ser-400, Ser-403 | To reveal the occurrence and development mechanism of PCa | (Russo et al., 2018; Z. Wu et al., 2023) |
| STAT3 | Tyr-705, Ser-727 | To elucidate the occurrence and development mechanisms of PCa, and to provide targets and possible drugs for the treatment of metastatic PCa | (Babaei, Khadem Ansari, Aziz, & Bazl, 2020; Henderson et al., 2019; Kwan et al., 2019; W. Lin et al., 2018) |
| p38 | Thr-72, Ser-74, Ser-77 | To elucidate the occurrence and developmental mechanisms of PCa and provide targets for PCa treatment | (Waseem, Khan, Haq, & Syed, 2022; Yuan et al., 2019) |
| ERK 1/2 | Thr-185, Thr-190, Thr-202, Tyr-187, Tyr-204, Ser-246, Ser-248 | Elucidation of the pathogenesis of PCa | (Borel et al., 2020; Zheng et al., 2020) |
| EGFR | Ser-695, Thr-693, Thr-678, | To reveal the occurrence and development mechanism of PCa and provide drugs for the treatment of PCa | (J. Li et al., 2022; P. Zhang et al., 2023; Zhi et al., 2018) |
| GSK3β | Ser-9, Tyr-216 | It is used to prevent or treat PCa metastases and is used to elucidate the occurrence and development mechanisms of PCa | (Barboro et al., 2020; Fang et al., 2020; S. Wu et al., 2018; S. Wu et al., 2021) |
| FOXO1 | Thr-24, Ser-249, Ser-256, Ser-319, Ser-322, Ser-325, Ser-329 | To elucidate the occurrence and development mechanisms of PCa and to provide a target for the treatment of PCa | (Cheng et al., 2023; Gheghiani, Shang, & Fu, 2020; Yan & Huang, 2019) |
| NANOG | Ser68 | Help identify new drug targets and improve treatment strategies for PCa | (Wang et al., 2019) |
| p65 | Ser-311, Ser-276, Ser-75 | To elucidate the occurrence and development mechanisms of prostate cancer and to provide a target for the treatment of PCa | (Bonacini et al., 2019; Q. Li et al., 2021) |
| SPOP | Ser-59, Ser-171, Ser-226 | WT-SPOP prevents the development of PCa | (Nikhil, Haymour, Kamra, & Shah, 2021) |
| p53 | Thr-18, Thr-55, Ser-20, Ser-46, Ser-315, Ser-392, Lys-372 | Switching off DDX49 is a promising new therapy for PCa patients | (Tao et al., 2023) |
| SHP1 | Tyr 536 | Dioscin can help treat androgen-sensitive PCa | (He et al., 2020) |
| Smad2 | Thr-220, Ser-245, Ser-250, Ser-255, Ser-240, Ser-465, Ser-467 | NR4A3 maintains MT-2 signaling to inhibit PCa cell invasion, tumor growth and metastasis | (H. Y. Lin et al., 2022) |
| c-Jun | / | JNK signal axis as a possible therapeutic target for PCa patients | (Schröder, Asimakopoulou, Tillmann, Koschmieder, & Weiskirchen, 2020) |
| EphA2 | Tyr-588, Tyr-594, Tyr-735, Tyr-930, Ser-897 | RES may have anti-Vasculogenic mimicry (VM) effects by inhibiting EphA3/twist-VE-cadherin/AKT signaling cascade in PCa PC-2 cells | (Han, Lee, & Lee, 2022) |
| Twist1 | Ser-68 | To better understand the occurrence and development mechanism of PCa | (Fan et al., 2019) |
| P-eIF2α | / | To better understand the occurrence and development mechanism of PCa | (Nguyen et al., 2018) |
| UHRF1 | Ser-298, Ser-639 | For the first time, a new molecular mechanism of abiraterone resistance via the PI3K/AKT-UHRF1 signaling pathway has been discovered | (Fu et al., 2023) |
| EphA3 | / | Providing a new biomarker for PCa | (Cai et al., 2022) |
| Plk1 | Thr-210, Ser-137 | To better understand the occurrence and development mechanisms of prostate cancer and to provide anti-prostate cancer medicines | (Z. Zhang et al., 2021) |
| ErbB2 | Tyr-1248 | MTE plays a potential antitumor role in PCa by inhibiting the ErbB2-GSK3β-HIF1α signaling axis | (X. Chen et al., 2022) |

**Table 3.** Summary of studies on the effects of protein ubiquitination on diagnosis, treatment and prognosis of prostate cancer

|  |  |  |  |
| --- | --- | --- | --- |
| protein | ubiquitination site | significance | reference |
| Caprin1 | / | To reveal the development mechanism of PCa | (Shi et al., 2019) |
| Cyclin E1 | Thr-77, Thr-395 | To reveal the development mechanism of PCa | (Ju et al., 2019) |
| EGFR | Lys-48, Lys-63 | To reveal the development mechanism of PCa | (Zhou et al., 2022) |
| STAT4 | Lys-350 | Providing a target for targeted PCa therapy | (Xiao et al., 2023) |
| HK2 | Lys-315, Lys-492 | A possible strategy to prevent chemotherapy resistance in prostate cancer is proposed | (Shangguan et al., 2021) |
| HDAC1 | Lys-444, Lys-476 | Uncover the mechanism of prostate cancer and create a new basis for targeted therapy | (Hao et al., 2022) |
| c-Myc | Thr-7，Ser-77 | Providing a target for targeted PCa therapy | (Ding et al., 2021; Ge et al., 2021) |
| SIX1 | / | Development of a novel and effective strategy to treat CRPC | (Y. Liao et al., 2022) |
| PTEN | Lys-13，Lys-289 | Elucidation of the origin and development mechanism of prostate cancer | (Deng et al., 2021) |
| CDKN1A | Ser-2 | Providing new prognostic and therapeutic targets for PCa | (Lai et al., 2021) |
| S100A9 | / | Providing a target for targeted PCa therapy | (Y. Zhang et al., 2022) |
| AR/  AR-V7 | Lys-48 | Uncover the mechanism of prostate cancer and create a new basis for clinical diagnosis and targeted therapy | (L. Gao et al., 2021; Liu et al., 2021; S. Lv et al., 2021) |
| RAB1A | / | SGOL2 promotes prostate cancer progression by inhibiting ubiquitination of RAB1A | (T. Lv et al., 2022) |
| Smad4 | Lys-519 | It offers a potential therapeutic strategy for advanced PCa treatment | (Gao et al., 2022) |

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